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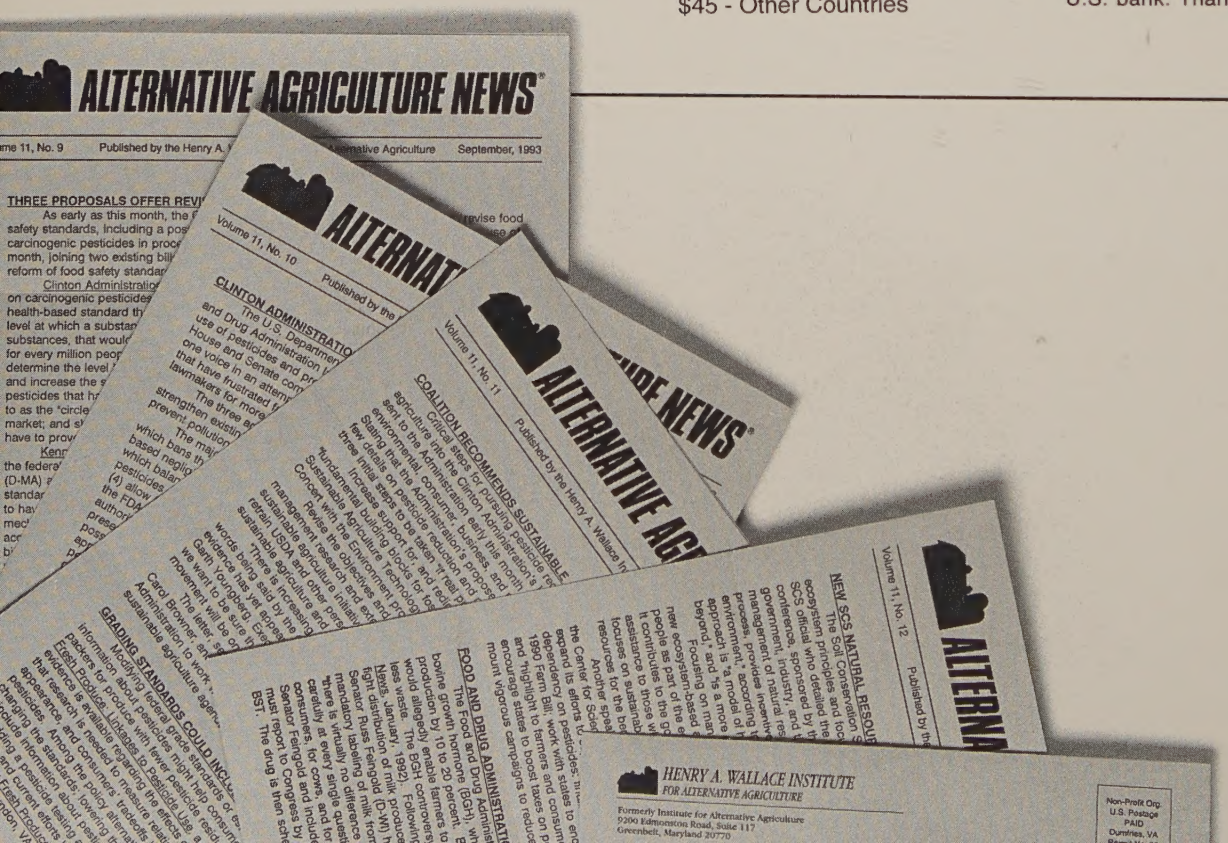

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Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

Cover Photo

Mixed crop-livestock production in the Middle East; in such a system, crop residues are used as animal feed, even when needed for soil and water conservation.

Introduction: Improving the sustainability of dryland farming systems in the Middle East

James F. Parr and Robert I. Papendick

Six papers in this issue were presented by Middle Eastern authors at the U.S.-Middle East Conference and Workshop on "Dryland Farming Systems and Technologies for a More Sustainable Agriculture," held at Moscow, Idaho on October 18–23, 1993. These follow a group of 13 papers by U.S. scientists published previously in this journal (Vol. 11, Nos. 2–3, 1996), on management strategies to improve soil quality and achieve more sustainable dryland farming systems in the Pacific Northwest Region (PNW) of the United States. As mentioned in the introduction to that issue, there are many similarities in dryland farming between these two distant regions. Both have winter precipitation patterns, low and erratic rainfall, light-textured soils subject to wind and water erosion, and cereal-based cropping systems for grain production. The differences are that the Middle East has a milder winter climate, higher temperatures, and a greater evaporative demand later in the growing season compared with the PNW. Another major difference is the extensive use of mixed crop-livestock systems in the Middle East in contrast to the PNW, where crop and livestock production are conducted as separate enterprises on different land. Thus, for U.S. farmers, crop residues and volunteer growth are largely available for return to the land, where they could improve soil productivity, enhance soil and water conservation, and provide a source of plant nutrients. However, in the Middle East, crop residues and weedy fallow are used mainly as livestock feed, with manure as the principal organic resource for improving soil productivity. Though similarities exist, differences in environment, production systems, land allocation and resources available for agriculture often prevent wholesale transfer of improved farming technologies from one region to another, or even among neighboring countries. Also, Middle Eastern soils have been cultivated for more than two millennia while those in the PNW have been farmed for little more than a century. Despite these differences, there are some exciting opportunities for international and regional collaboration and for exchange of information among scientists and farmers that can enhance the sustainability of dryland farming systems through improved conservation practices, selective inputs, and more efficient use of natural resources.

There is an urgent need in most countries of the Middle East to increase food production for an ever-increasing population and for improving the health and nutrition of people. In recent decades, food production goals have focused mainly on expanding the area under irrigation. Today, however, a critical shortage of water available for irrigated agriculture has developed throughout the region because of increased demands for fresh water for urban development and industrialization. Environmental pollution of surface water and groundwater further limits the availability of water for all uses. Consequently, the lack of good quality water for agriculture is beginning to threaten long-term food security in much of the region. This situation also has raised questions about the sustainability of irrigated agriculture and whether continued irrigation development, despite its costs, can meet future food demands.

It is noteworthy and ironic that, in comparison, little time or money has been invested to improve the productivity and efficiency of rainfed agriculture. This is particularly true in the underdeveloped drylands where low-technology crop production has a much greater economic risk than that of irrigated agriculture. This presents a special opportunity for increasing food production in the future. Conserving and using the natural rainfall more efficiently for crops results in little or no dependence on water from other sources, and the new technology holds considerable potential for increasing and stabilizing crop yields.

The key to using rainfall more efficiently is improved crop and soil management practices. Papers from the six Middle Eastern countries represented at the Conference describe Middle Eastern conditions and various agronomic, environmental, and socioeconomic aspects of their dryland agriculture. The authors discuss constraints that need to be addressed and opportunities for achieving sustainable food production under low rainfall conditions. This dialogue should help create opportunities for scientists in the region to interact and work together to solve common technical problems that transcend borders and sociopolitical differences.

Problems common to rainfed agriculture in most Middle Eastern countries include limited potential for expanding areas for agricultural production, deteriorating environmental conditions, depletion of natural resources, land fragmentation, declining soil productivity, and inadequate soil and water conservation measures. A.Y. Taimeh and N. Katkhuda report that Jordan's limited productive land resources coupled with the population growth have resulted in a steady decline in food self-sufficiency for

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most commodities. To achieve sustainable development in dryland agriculture they emphasize the need for conservation, efficient use and development of available land resources, and maximum use of modern technologies such as mechanization, improved crop varieties, and judicious use of fertilizers and pesticides. A. Yahyaoui and colleagues conclude that in Tunisia, improved crop varieties will be of little benefit to the farmer and will not achieve their full yield potential without good crop and soil management techniques. They also emphasize that the yield potential of new varieties should be evaluated with proper management and inputs within the particular agroecological zone and production system in which the crop will be grown.

J. Isaac and S. Gasteyer report that the most important development that increased crop yields in Palestine was an expansion of the irrigated area. However, opportunities for further expansion are diminishing and there is a growing awareness that sustainable agriculture in the future for much of the Middle East will depend on improving the productivity of rainfed farming, particularly in the low rainfall areas. Experiments and demonstrations in Palestine have shown that there is considerable potential for improving the productivity, economic return, and sustainability of this underdeveloped sector of agriculture.

N.G. Seligman and colleagues report that in Israel less than half the area devoted to field crop production is irrigated. Problems that confront dryland agriculture in particular are primarily related to achieving economic sustainability. These authors say that there is an urgent need for more appropriate dryland production systems and associated innovative research and development. They also mention that many challenges with sustainable dryland farming are the same among Middle Eastern countries and offer opportunities for regional and international collaboration. A. El-Beltagy and colleagues stress the need for developing and implementing water management strategies in Egypt to enhance water-use efficiency in crop production as a way to achieve food self-sufficiency. The country has given considerable attention to building its capability for developing sustainable agricultural water management systems.

Turkey, like other Middle Eastern countries with expanding populations and limited land resources, also is seeking to achieve national food self-sufficiency. According to M.S. Yesilsoy and S. Ersahin, the primary wheat production objectives before 1990 were achieving high crop yields and high economic returns. However, new national objectives for more sustainable production were established in early 1990 with the goal of developing ecologically sound farming systems that would achieve higher economic yields per unit area. The key to this approach is to enhance soil quality by adopting farming practices that maintain or increase soil organic matter. These Turkish scientists agree with others that soil quality is the key to sustainable agricultural development. This approach should serve as a fundamental guide to scientists and farmers in both the Middle East and the United States as they work to improve the productivity and sustainability of the dryland areas.

Acknowledgments. We thank all the authors for their excellent contributions to the conference/workshop and for their papers in this issue. Moreover, the acknowledgments in the introduction to the earlier conference papers also apply here. We also thank the anonymous reviewers who contributed generously of their time and effort in reviewing these manuscripts.

U.S. Geological Survey Finds Widespread Pesticides in Water

The first cycle of the U.S. Geological Survey's National Water Quality Assessment has found widespread pesticides in streams and groundwater, with most of the 84 pesticide compounds investigated detected in those waters at least once, according to a preliminary summary of the assessment's first results. The assessment was conducted on 5,000 samples of groundwater and surface water in 20 major hydrologic basins from 1991 to 1995, predominantly in agricultural and urban settings.

The data collected are the most extensive ever compiled for such a wide range of pesticides and locations. The 84 pesticides investigated account for approximately 75% of the agricultural uses and a substantial portion of urban and suburban uses in the United States.

The assessment found pesticides more often in streams than in groundwater, with most streams containing low-level mixtures of pesticides during much of the year. Other findings include:

- At least one pesticide was found in every stream and in half the wells sampled. There was an average of seven to eight pesticides in each stream sample.
- The same herbicides were most commonly found in streams and groundwater: atrazine and metolachlor, used primarily on corn and soybeans; prometon, used primarily in urban and suburban settings; and simazine, used in both agricultural and non-agricultural settings.
- Insecticides were not found often in groundwater, but those most frequently detected in streams were diazinon, chlopyrifos, and carbaryl, all of which have substantial urban and suburban use.

The final assessment and other publications related to the assessment are expected to be available by the end of this year. For more information, contact Tim Miller, Chief of the National Water Quality Assessment, at (703) 648-5716.

SARE Requests Proposals for Innovative Marketing Strategies

The North Central Region Sustainable Agriculture Research and Education (SARE) program is requesting applications for competitive grants addressing Innovative Marketing Strategies. Priority areas include improving producers marketing relationships with local and regional consumers and businesses, assisting with development of community markets, and examining consumer preferences of local food. The call for proposals is available on the World Wide Web at http://www.ces.ncsu.edu/ncrsare.

For more information, contact the NCR SARE Office at (402) 472-7081; e-mail sare001@unlvm.unl.edu. Proposals are due January 23, 1998.

Dryland farming systems in Jordan

Awni Y. Taimeh and Nabil Katkhuda

Abstract. *Resources available for dryland farming in Jordan are limited since 91% of the country has an arid climate. Moreover, the available resources are subject to a wide range of natural and human constraints. The farming systems consist of two main types: annual crops such as wheat and barley, and fruit trees such as olives, grapes, and stone fruits. Socioeconomic factors coupled with a fluctuating rainfall pattern cause some shifting in land use and variation in land under cultivation. Alternative land use strategies and preservation and more efficient use of resources are the means to achieve higher production. Substantial addition of land suitable for cultivation is unlikely since it would require additional water resources, which are diminishing in Jordan. Environmental degradation such as desertification is a major concern to land use planners. Several issues must be addressed if agricultural productivity is to be sustained: preservation of resources; overcoming various pressures imposed on agricultural lands; adoption of new practical and economical practices; introduction of modern technologies such as water harvesting, supplemental irrigation, use of treated waste water, and proper soil conservation measures; and adaptive research.*

Key words: arid climate, water resources, irrigation

Available Agricultural Resources

The total area of the Hashemite Kingdom of Jordan is about 89.2 million km^2. This land is distributed among four agroclimatic regions, primarily determined by climate (Table 1).

Land resources

Productive agricultural land is limited in Jordan. The most important limiting factor is scarce and erratic rainfall. Almost 90% of Jordan's land is classified as semidesert, receiving less than 200 mm annual rainfall. The remaining 10%, distributed over three agroclimatic regions, is the main area suitable for rainfed agriculture (Table 1). About 93% of the cultivated land is located in what is called the Highlands where most of the population centers are concentrated.

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Table 2 shows the distribution of land by slope within the rainfed areas. Land on slopes of 0–8% is suitable for field crops. Land with slopes greater than 8% is generally more suitable for fruit production than for grain, while slopes greater than 25% are generally more suitable for forestry than for farming.

Rainfall and slope are the two major criteria used to classify the suitability of land for rainfed agriculture. Soil depth and texture also are important, but no general criteria have been established for these factors since the soil map for the whole country is not complete. About 50% of the cultivated rainfed area (395 thousand ha) lies within the 200–300 mm rainfall zone. The soil here is of low fertility and has other unfavorable properties. Furthermore, about 40% of the total cultivated area has slopes of 9–25%.

The land in the 300–400 mm zone is considered most suitable for the production of different crops and has the least severe technical constraints. Where annual rainfall is greater than 400 mm, crop production is limited mainly by soil depth and slope. However, because of its lower water stress, it is most responsive to suitable management.

The limited productive land resources, coupled with the population growth, have decreased self-sufficiency in most food commodities. There are indications that by the year 2000, Jordan will be about 7–8% self-sufficient in cereals and about 14% self-sufficient in food energy. This emphasizes the urgent national need to focus on conservation, the development and efficient use of available land resources, and maximum use of modern technologies.

Present land use

Agricultural land use in Jordan is highly dependent on the amount of rainfall. Rainfed agriculture is largely restricted to areas with annual rainfall >250 mm. The rest of the country is used as range. Irrigated agriculture is practiced wherever water is available. Unfortunately, urban activities are often concentrated in areas suitable for rainfed agriculture. Table 3 gives the

Table 1. Agroclimatic regions in Jordan.

	Area		
Region	**1,000 ha**	**%**	**Annual Rainfall (mm)**
Semidesert	8,094	90	<200
Arid	563	6.3	200–350
Semiarid	136	1.5	350–500
Semihumid	98	1.1	>500

Table 2. Distribution of rainfed areas according to slope and average annual rainfall (1,000 ha).[1]

Rainfall (mm)	Slope						Total	
	<9%		9–25%		>25%			
200–300	130.2	(16.3%)	175.8	(22.1%)	89.1	(11.1%)	395.1	(49.5%)
300–400	59.2	(7.4%)	79.9	(10.1%)	40.5	(5.1%)	179.6	(22.5%)
>400	73.7	(9.2%)	99.4	(12.4%)	50.4	(6.3%)	223.5	(28.0%)
Total	263.1	(32.9%)	355.1	(44.6%)	180.0	(22.5%)	798.2	(100%)

[1] Source: Jordan Ministry of Agriculture.

Table 3. Distribution of land use in 1988.

Land Use	Area	
	1,000 ha	%
Pasture lands in Bedouin and semidesert regions	7,558	84.7
Buildings and public utilities	668	7.5
Forests	140	1.6
Agriculture	554	6.2

distribution of land use in Jordan for both agricultural and nonagricultural sectors. The area used for agriculture is about 414 thousand ha, or about three-quarters of the land potentially fit for agricultural use. Production on 353 thousand ha of this land depends on rainfall; 61 thousand ha is under irrigation. Other areas designated for agricultural use are in the Highlands and the Jordan Valley.

The nonirrigated land (in thousand ha) is used as follows:

- fruit trees and olives (*Olea europaea*): 68
- winter or summer field crops: 156
- tobacco (*Nicotiana* spp.): 3
- summer vegetables: 8
- left fallow or neglected: 118.

Detailed information on land planted to specific cultivated crops is presented in Table 4. The area planted with field crops varies widely from one year to the next because of the high variability of annual and within-season rainfall.

Water resources

Both the future development of rainfed areas and the maintenance of current irrigated areas depend largely on available land resources and future projections. Rainfall is the major source of surface and underground water in Jordan. Annual rainfall ranges from 50 mm in the desert regions to about 600 mm in the eastern mountains adjacent to the Jordan Valley.

Of the renewable surface water, only 470 million m^3 (MCM) is currently used. Among the reasons for this are:

- The low use of the Yarmouk river (estimated to be 100 to 125 MCM out of a total of 400 MCM)
- The low use of surface and flood water in valleys.

At present, the total amount of water that can be economically used is about 865 MCM, distributed as follows:

- surface water: 470
- renewable underground water: 270
- nonrenewable underground water: 125.

Future development in agriculture and industry and the rapidly increasing population will add to pressures on conventional water resources. Projected shortfalls in Jordan's water supply will increase rapidly in the 21st century (Table 5).

The gap between available water resources and demand is rapidly increasing. However, conservation of water resources in rainfed areas is possible through several measures, including reuse of urban treated waste water, water harvesting, aquifer recharge, check dams, and cultural practices.

Production Systems in the Rainfed Areas

Production systems in the rainfed areas can be broadly divided into two groups: those based on annual crops, and those based on perennial crops. The main annual crops are wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), lentil (*Lens culinaris*), and chickpea (*Cicer arietinum*). The main perennial crops are olives, grapes (*Vitis* spp.), and stone fruits. Land shifts continuously between field crops and fruit trees, especially good land with least production constraints, regardless of rainfall patterns. There also is a seasonal fluctuation in the average areas planted with different crops.

Table 4. Use of cultivated areas, 1985–89 (1,000 ha).

Crop	1985	1986	1987	1988	1989	Average
Field Crops						
Winter	1449	768	2023	1971	1438	1530
Summer	39	24	19	39	36	31
Tobacco	56	25	32	36	34	37
Irrigated vegetables	406	313	279	259	246	301
Nonirrigated vegetables	97	49	59	115	53	75
Olives	285	351	372	406	421	367
Citrus	49	50	52	53	53	51
Others	168	181	193	201	210	191
Total	2549	1761	3029	3080	2490	2582

Table 5. Projections for water use and availability in Jordan (million m^3).

Year	Consumption	Available	Shortage
1990	740	715	25
1995	890	865	25
2000	1045	865	180
2010	1430	865	565
2020	2145	865	1280

Wheat. Wheat is the main field crop in areas with more than 300 mm annual rainfall. Wheat straw is a valuable by-product that is used for livestock feed. During 1986–1990, wheat planted per year averaged approximately 87 thousand ha (Table 6) while annual production averaged 81 thousand tons. Average yield of wheat varied between 680 kg/ha (1981–1985) to 924 kg/ha (1986–1990) because of shortages and erratic distribution of rainfall. Improved practices, including high yielding varieties, seed drills, early planting, fertilizers, and herbicides, have increased wheat yields.

Barley. Barley is an important crop in the rainfed areas, and is used mainly for livestock feed. It is the dominant cereal in areas with less than 300 mm annual rainfall because of its tolerance to water stress and poor soil conditions. Average yield during 1981–1985 was 460 kg/ha. Productivity increased to 720 kg/ha during 1986–90.

Lentil and chickpea. Lentil and chickpea are grown as a part of the cereal crop rotation but not systematically. Under present conditions, average yield depends mainly on the amount of rainfall.

Summer crops. Summer crops are mainly vegetables and tobacco planted in rotation. The area planted with summer crops depends on rainfall during the previous winter.

Perennial Crops. Fruit tree plantations are encouraged by the government, especially for small farms in mountainous areas. Because of their high profitability, fruits now compete with grains for the best soils on flat land. The most important fruit trees grown in this area are:

- Olives. Olive trees are indigenous to the region. They tolerate harsh conditions, including poor soils and drought. Until 1991, the total area planted to olives under rainfed conditions was 54.7 thousand ha, of which 40.2 thousand ha were in production.
- Grapes. Grapes are usually grown on steep land with shallow soils. Both local and introduced varieties are of the table grape types. Soil conservation projects supported by the government greatly expanded the area in grapes.
- Stone fruits. Stone fruits include peach (*Prunus persica*), almond (*P. amygdalus*), plum (*Prunus* spp.), and apricot (*Prunus* spp.). The main crop in this group is peach. During 1981–90 the area planted to peaches increased by 50% over the previous decade.
- Pome fruits. The area planted with pome fruits consistently increased during 1981–92 (Table 6). New high-yielding dwarf varieties of apple (*Malus* spp.) were recently introduced to the country.

Table 6. Cropping patterns in rainfed areas, 1981–92 (1,000 ha).[1]

	1981–85	1986–90	1991–92
Wheat	860	878	651
Barley	361	433	518
Lentil and chickpea	68	79	49
Vegetables	20	31	54
Tobacco	72	31	21
Olives	299	400	548
Grapes	92	167	108
Stone fruits[2]	17	25	27
Pome fruits[3]	6	10	18

[1] Source: Jordan Ministry of Agriculture.
[2] Peaches, plums, apricots and almonds.
[3] Apples and pears *(Pyrus communis)*.

Livestock feeds. The rainfed areas also are a major source of feeds for livestock. During 1989–1991, the average feed supply (thousand tons) was estimated as follows:

- hay from legumes: 5.2
- wheat and barley hay: 66
- barley: 34
- vetch: 1.4
- wheat bran: 10

Increasing Agricultural Production

Increasing agricultural production is expected to be achieved in several ways:

- Increasing the agricultural area by bringing previously unused but potentially productive lands under cultivation
- Increasing the cropping intensity
- Increasing the yields through proper soil conservation measures, management practices, and antidegradation measures.

Use of these three strategies depends on and is linked with prevailing economic and social conditions.

Increasing the area of agricultural lands

There is only limited potential in Jordan to bring previously unused but potentially productive land under cultivation. Population pressure has resulted in industrial and residential encroachment on lands that may have been suitable for sustainable agricultural use. The total area with average annual rainfall of 200 mm or more is about 800 thousand ha. Of this, 12.5% receives >500 mm, 17% receives 350–500 mm, and 70.5% receives <350 mm. Land use in this region (200 mm annual rainfall or more) is presented in Table 7.

Some 50 thousand ha in this region can be made available for utilization by agriculture. These are in areas receiving <200 mm annual precipitation and are suitable for irrigated crops. Thus, the total area that can be used for agriculture is 402 thousand ha, with 352 thousand ha now under cultivation. About 63 thousand ha in this region is totally unused. Although there is no classification of this unused land, it is known to consist mostly of stony land with shallow soils. Average slope ranges from 9 to 25%. Most of these lands receive very low rainfall (200–250 mm). Thus, there is very little potential in Jordan to add to existing

Table 7. Use of land receiving 200 mm or more average annual precipitation (1,000 ha).

Cultivated	352
Forest	74
Assigned for forest	77
Privately owned, steep, unsuitable for cultivation	50
Rehabilitated pasture and range	3
Surface water	10
Urban	169
Unused	63
Total	798

agricultural land. There also is a decrease in the area available for agricultural production because of the accelerating changes toward nonagricultural uses and the degradation of resources by desertification.

Increasing cropping intensity

Because of the limited potential for expanding the area in cultivation, increasing agricultural production will require an increase in cropping intensity, especially in the nonirrigated regions. About 290 thousand ha is suitable and currently cultivated for field crops without irrigation. Most of this land is in essential field crops such as wheat, barley, lentil, chickpea, and vetch (*Vicia* spp.). About 42 thousand ha is in fallow in the zone receiving 300 mm annual rainfall, or about 32% of the total cultivated area in that rainfall zone.

Approximately 140 thousand ha of cropland is in the zone of 200–300 mm annual rainfall, about one-half of which is in fallow in rotations of wheat and barley. About 50 thousand ha of this fallow can be replaced by pasture forage cultivation. If only barley is grown, the barley grain and legume hay could be used to feed sheep during periods of insufficient grazing and forage on the pastures. The productivity of these areas also could be increased and stabilized through supplemental irrigation from water harvesting, and through land application of treated wastes to improve soil fertility.

The optimum way to use land in the 100–200 mm annual rainfall zone, about one million ha, is to develop natural pastures to combat desertification through water and soil conservation measures, and planting of pasture and forage plants and shrubs. Water resources needed for such development can be made available through supplemental irrigation, water harvesting, treated waste water, and proper range management. However, it first is necessary to determine optimal land use strategies and appropriate agricultural practices to overcome any socioeconomic constraints. In summary, there is a potential for increasing the nonirrigated cultivated area in Jordan by increasing the cropping intensity on about 90 thousand ha. This alternative is feasible if additional research is carried out and if inputs, machinery and marketing services, financial support, and credits are made available.

Increasing the productivity of the land

In view of the limited agricultural resources in Jordan and the constraints on putting new land under cultivation, a strategy to complement increased cropping intensity for increasing production is to raise the productivity per unit of agricultural land. Current yields are low compared to those achieved through the new technologies or by adopting proven technologies from comparable agroecological environments in other regions of the world.

Results of agricultural research on wheat and barley indicate the following potential yield increases:

- wheat: from 800 kg/ha (average 1985–1989) to about 2200 kg/ha.
- barley: from 630 kg/ha to about 2500 kg/ha.

Also, there are opportunities for increasing yields from the current plantings of olives, citrus, prunes, and grapes. These include proper pruning, fertilizing and pest control, and selecting specific varieties and cultivars of trees best adapted to particular agroecological environments.

There also are opportunities for increasing the productivity of natural pastures in the 100–200 mm annual rainfall zone. The current yield is about 1 nutritional unit per ha. This could be substantially increased through conservation measures and regulation of grazing rotations. Pasture yields could be further increased through planting of shrubs. Controlled grazing and introduction of forage shrubs increases yields to about 850–1200 kg/ha on these lands.

Agricultural Research

Agricultural research should be based on the following principles:

- Agricultural production systems that are adopted should be suitable for specific agroecological environments.
- Objectives adopted for future agricultural research and development should identify both short-and long-term strategies for solving problems in agriculture.
- Agricultural research should follow a commodity principle, and there should be a ranking system to determine the research priorities according to the economic value of each product and its importance for small farmers.
- An integrated approach should be adapted to achieve development objectives by combining the research results into an effective package for technology transfer, and by establishing improved service structures.
- Technology transfer should be an integral part of the comprehensive agricultural research package. A proper strategy for technology transfer should consider local conditions and farmers' ability to accept new technologies.

Preservation of Agricultural Resources

In optimizing agricultural production systems, natural resources must be used in a way that preserves and sustains them. Jordan is facing an increasing deterioration of the natural environment as a result of several factors:

- The destruction of the vegetation cover on pasture land has been accelerated by competition for land, tillage to claim ownership, and heavy traffic movement.
- The depletion, pollution and salinization of ground water has been aggravated in some regions by approval of excessive pumping beyond safe limits.
- The aggravation of environmental damage in part has resulted from lack of government legislation for conservation of natural resources.

Desertification

Desertification is the combined effect of several degradation processes, including erosion by water and wind, reduction of vegetation cover, salinization by human activity, and the development of unfavorable soil properties. This process is very important in Jordan.

Ecologically, Jordan can be divided into the following agroecological zones:

Rift Valley (Jordan Valley). The climate of this zone is characterized by high temperature and a gradual decrease in rainfall from north to south. Irrigated agriculture is mainly practiced in this zone (23.3 thousand ha).

Eastern Plateau (Highland). Annual precipitation varies from 250 to 600 mm. Most rainfed agriculture is concentrated in

this zone, which includes approximately 900 thousand ha.

Steppe zone. Annual precipitation varies from 150 to 250 mm. The total area is approximately 600 thousand ha.

Eastern Desert. This zone comprises about 91% of the total land area of Jordan. The annual precipitation varies from 150 to 250 mm. This zone can be divided into two subzones: the Eastern and Northeastern; and the Southern and Southeastern. The division of the zone is based on the geological formations. Consequently, there are different forms of desertification within each subzone. Different soils with varying potentials for production can be found, depending on the parent rocks and topography.

The general status of desertification in Jordan is as follows:

- Several indicators have been observed within the Eastern Plateau that reflect the influence of desertification: substantial reduction in plant density; high rate of erosion by water; reduction of forest area; and accumulation of calcareous silt at the soil surface from long-term wind erosion. The high variability of the annual precipitation is crucial in further degradation.
- The greatest desertification in this zone is due to high rainfall fluctuation and mismanagement of land. This leads to higher rates of wind and water erosion, which lead to unfavorable soil properties and reduced soil productivity. Nevertheless, the soils of this area have a good production potential, as shown by recovery of various plant species shortly after protection measures are applied. The rapid plant regeneration in the protected areas, in comparison with the thin plant cover of open areas, clearly shows how human interference enhances desertification in this zone.
- Advanced desertification characterizes the Eastern Desert, as shown by the existence of extensive flat areas covered with desert pavements, the absence of plant cover and the high salt content in some areas. Sand dunes, an indicator of severe desertification, start to form at the eastern and northeastern borders between Jordan and Saudi Arabia. In the southern and southeastern zones, the advanced rate of desertification is indicated by the dominance of sand dunes and the extensive open sandy areas covered by desert pavement with almost no plant cover. However, some plant species can be found inside waterways.

Changes in Rainfed Agriculture

Land use and allocation. The total area of registered agricultural land holdings decreased from 367 thousand ha in 1975 to 340 thousand ha in 1983. The decrease was probably from loss of land to population centers that originally were established within agricultural areas. Further urban expansion is expected to occur at the expense of agricultural land as Jordan's population doubles every 19 years.

Land fragmentation. Inheritance law and free land sale have increased fragmentation in the rainfed areas. However, from 1975 to 1983, the number of farm holdings less than 4 ha increased from 25,190 to 32,400, and holdings less than 2 ha increased from 17,090 to 23,000. Small holdings limit the use of new technology for field crops because they usually require the use of special farm machinery and do not generate enough income to support an average rural family.

Soil and water conservation. Since 1964, the Jordan Ministry of Agriculture, with the support of the World Food Program, has had a soil and water conservation program for all hilly areas with a slope of 9–25%. In 1987, the government implemented another project, "The Development of the Zarqa Catchment Area," for land and water conservation and agricultural development.

Constraints on Rainfed Agriculture

Socioeconomic constraints. Rainfed areas have experienced enhanced rural development associated with changes in many aspects of life patterns, education, health care, social services, and infrastructure. These changes have created a greater need for adequate and stable incomes for farmers. However, the uncertainty of income under the existing farming system has forced farmers to seek jobs outside the agricultural sector. This has led them to neglect the land and rely more on unskilled foreign labor.

Shortage of labor. In general, there is no shortage of unskilled labor. However, the ever-increasing cost of labor and inputs, without a corresponding increase in the value of crops produced, has adversely affected the production of many crops that depend on hand labor, such as chickpea and lentil.

Urban expansion. Urbanization is progressing rapidly at the expense of good arable land. The high value of land in urban areas is a main pressure for expanding the boundaries of villages and municipalities at the expense of productive land.

Low productivity. Low production potential is mainly related to the erratic and limited rainfall. Land potential in the different agroclimatic zones has not been adequately evaluated and should be fully investigated. However, economic constraints often have been the main factor limiting improvements in productivity.

Technical constraints. New technical information and know-how need to be integrated to implement operational packages. Such packages should be able to provide properly balanced and efficient use of land and water as a part of integrated farming systems.

Research and extension. Extension is a weak link in the application of improved technology in Jordan. Extension services need to be improved to undertake transfer of improved technological packages in cereals.

Shortage of skilled agricultural labor. The rainfed areas have markedly expanded the production of fruit trees. Fruit production requires a considerable amount of skilled labor for managing the different inputs, including application of fertilizers and chemicals and operation of farm machinery.

Priority Issues

The following issues are most crucial for the preservation and development of land resources for sustainable agriculture in Jordan's rainfed areas.

- Soil conservation
- Combatting of desertification
- Use of waste water and supplemental irrigation
- Moisture-conserving farming practices
- Integration of reclamation of steep land and harvesting with appropriate farming practices
- Optimal land use alternatives
- Research on environmental stresses
- Use of treated sewage sludge
- Strategies for optimal use of arid and semiarid land.
- Groundwater recharge technology.

Effect of cultural practices on barley and durum wheat yields in semiarid regions of Tunisia

A. Yahyaoui, K. M'Hedhbi, and S. Rezgui

Abstract. *The semiarid regions (SARs) are characterized by extreme temperature changes, low and unevenly distributed precipitation, hazardous torrential rains, and frequent early spring droughts. Barley is the most highly adapted cereal in SARs, but durum wheat is the most widely cultivated. The area in cereals varies considerably from year to year, and yields are low. Tillage practices are used to conserve both soil and moisture and to prepare the seed bed. However, improved fertilizer use and weed control practices are not being used. Without development of needed cultural and tillage practice systems, the genetic potential of today's varieties cannot be realized. Planting depth and rate, row spacing, fertilizer application, and weed control were investigated under conventional tillage and reduced tillage systems. In on-farm trials, reduced tillage did not significantly affect durum wheat yield but slightly increased barley yield compared with traditional practices. Optimum planting depth for both wheat and barley was 7 cm. Higher seeding rates increased the yield of both crops. Highest yields were obtained at planting rates of 140 kg/ha for wheat and 100 kg/ha for barley. At these rates, maximum yields were achieved at row spacings of 30 cm for barley and 20 cm for durum wheat. Use of fertilizer and weed control increased yields substantially. Sustained and increased production in SARs can be achieved with a "package of practices" approach that incorporates these cultural and tillage practices.*

Key words: tillage, planting depth, seeding rate

Introduction

About one-third of the world's 1.4 billion ha of cultivated land is in semiarid regions (SARs) (Oxford University Press, 1972). Central and southern Tunisia and a large part of northwestern Tunisia are semiarid. The SAR accounts for 71% of the country's total cereal area (Ministère de l'Agriculture, 1992). However, cereal production is only 50% of national needs. National and international breeding programs have developed wheat (*Triticum* spp.) and barley *(Hordeum vulgare)* varieties that perform well under optimal conditions, particularly in northern Tunisia. However, in the low rainfall areas (Table 1), cereal yields have not been substantially improved by new varieties when grown under the management practices traditionally used. To meet national cereal production requirements in Tunisia, an improved package of cultural practices must be developed to use the high yield potential of new varieties.

Varietal Adaptation

Crop production in dryland regions increases when better-adapted varieties are combined with improved soil and crop management techniques (Hepworth et al., 1975). The yield performance of traditional and new wheat and barley cultivars grown under optimum management practices in the SAR of Tunisia during the 1992–93 crop season are shown in Table 2. Average yield varied from 971 to 2077 kg/ha for durum wheat *(Triticum durum)*, 1650 to 2015 kg/ha for bread wheat *(T. aestivum)*, and 2362 to 3006 kg/ha for barley. The varieties are listed in order of release; for instance, the durum wheat variety 'Ajili' has been cultivated since the early 1900s and 'Chili' since the 1950s, and 'Om Rabia' is being introduced. Likewise, the bread wheat variety 'Fl. Aurore' has been commercially grown since the mid-1970s. For barley, 'Rihane' was released in the mid-1980s, but 'Martin', introduced in the 1950s, is still the major variety in production. In all cases, there is a net increase in the yield potential of the different cereal varieties through the years, though the increase is more marked for durum wheat.

The advantage of increased yield potential with new varieties is often lost if proper crop management techniques are not used. Average farm yields in the SAR of Tunisia under traditional crop management practices are still very low, despite the use of improved cultivars. Table 3 shows the average yield in different cereal production areas in the SAR and the nation (Ministère de l'Agriculture, 1993).

Economic yield is increased by planting the most highly adapted variety available. To verify yield potentials, varieties need to be tested under the climatic, soil, and management conditions prevalent in the area where they will be grown. Available commercial cereal varieties have been tested at three sites within the SAR. Table 4 shows the ranking of four durum wheat and six bread wheat varieties. 'Razzak', a durum wheat, and 'Salambo', a bread wheat, were the most adapted varieties at the three testing sites. Varieties intended for dryland production should have an inherent ability to sustain yield under changing environments.

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Table 1. Monthly rainfall (mm) at three sites, 1992–93, in the semiarid regions of Tunisia.

Site	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun–Aug	Total	Average (60 yr)
Siliana	24	22.5	89.5	60	20.5	15	56.5	0	58.5	Trace	346.5	415
Kef	4	33	72.5	51.5	25	37.5	34	0	49.5	Trace	307.0	490
Zaghouan	14.3	31.7	77	55.4	31.9	24.1	44.1	3.5	40.7	Trace	322.7	495

Table 2. Grain yield (kg/ha) of commercial durum, bread wheat and barley cultivars at three sites in Kef Governorate, 1992/1993.

Crop/Variety	Tajerouine	Sers	Zaafrane
Durum wheat			
Ajili	933	1300	680
Chili	1600	1800	1125
Inrat 69	2066	2300	1500
Karim	2400	2100	1370
Razzak	2533	2200	1500
Om Rabia	—	2650	1370
Bread wheat			
Fl. Aurore	1600	2050	1305
Dougga	2200	2200	1300
Tanit	1933	2400	1500
Byrsa	2466	2400	1180
Barley			
Land Race	2000	2650	2437
Martin	1933	3400	2250
Rihane	2133	3700	3187

Table 3. Average cereal yield (kg/ha) at three SAR locations.

Governorate	Durum wheat	Bread wheat	Barley
Siliana	1700	1800	1350
Kef	1200	1280	1280
Kasserine	570	630	600
National	1320	1610	930

Table 4. Average grain yield (kg/ha) of durum and bread wheat cultivars grown at three SAR locations, 1992–1993.

Kef	Siliana	Zaghouan	Average
Durum wheat			
Razzak	4242	4422	2683
BD2335	4415	3910	2432
Karim	4157	3342	2426
Inrat 69	3767	3612	2153
Bread wheat			
Salambo	4434	4364	2154
Tanit	4491	3738	2209
Dougga	4269	3568	2348
Bryrsa	3880	3738	2042
Ariana	3210	3851	1958

Cultural Practices

The genetic potential of new varieties cannot be achieved unless appropriate cultural practices are implemented. Several studies conducted in different dryland regions of the world have shown that seeding rates, planting depth, row spacing, and tillage methods are the most important cultural practices to consider when attempting to increase production.

Planting methods

Seed zone water content is a critical factor for successful stand establishment of cereals in the SAR of Tunisia. The seed must be placed at a depth where adequate moisture for germination is available. Failure to achieve good germination and emergence decreases early growth and limits yield. On-farm trials at planting depths of 4, 7, and 10 cm showed that planting depth influenced yields of both durum wheat and barley (Fig. 1). The highest yields of both barley and wheat are obtained at a planting depth of 7 cm in a SAR climate with current cultural practices. Planting shallower or deeper than 7 cm limits stand establishment either by decreasing germination or by reducing emergence.

Several studies conducted in different dryland regions of the world have shown that seeding rates can be reduced and row spacings increased without reducing grain yields (Alessi and Power, 1971; Bolton, 1973; Guler, 1975). Plant populations and distribution must be adjusted either within rows or between rows because of seeding method and crop characteristics. Increasing the distance between plants within rows and reducing distance between rows to achieve a more uniform distribution may be ineffective with limited moisture. Efficient use of limited moisture is possible only with careful attention to plant population and distribution in dryland areas (Arnon and Blum, 1964; Arnon, 1972). Crop species and varieties may differ in their response to seeding

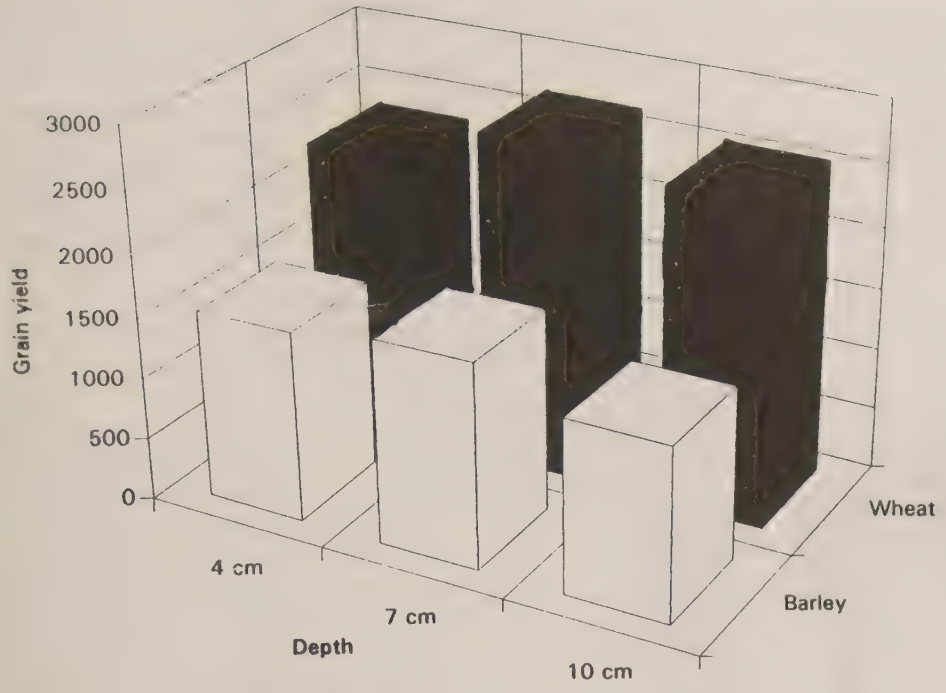

Fig. 1. Grain yield (kg/ha) of wheat and barley at different seeding depths.

rates and row spacing in different climatic zones. Guler (1975) found that some varieties had different optimum plant populations at different locations, while other varieties responded uniformly at a given seeding rate at several locations. Seeding rates tested in large-scale experiments in the SAR showed a greater effect on yield of barley than of durum wheat (Figs. 2 and 3).

The highest barley yield was observed at a seeding rate of 100 kg/ha, whereas the greatest durum wheat yield was achieved at the highest seeding rate (140 kg/ha). On-farm trials using different seeding rates and row spacings showed a significant effect on wheat and barley yields. Performance of durum wheat (cv. 'Inrat 69') and barley (cv. 'Rihane') over two years at a representative site (Kef) in the SAR is shown in Table 5. Barley yields were greatest (3834 kg/ha) when planted at a row spacing of 30 cm and a seeding rate of 100 kg/ha, whereas durum wheat yielded best (2713 kg/ha) when planted in 20-cm rows at a high seeding rate of 140 kg/ha. Differences in tillering ability could account for yield variations of the two crops at different row spacings and seeding rates under dryland conditions.

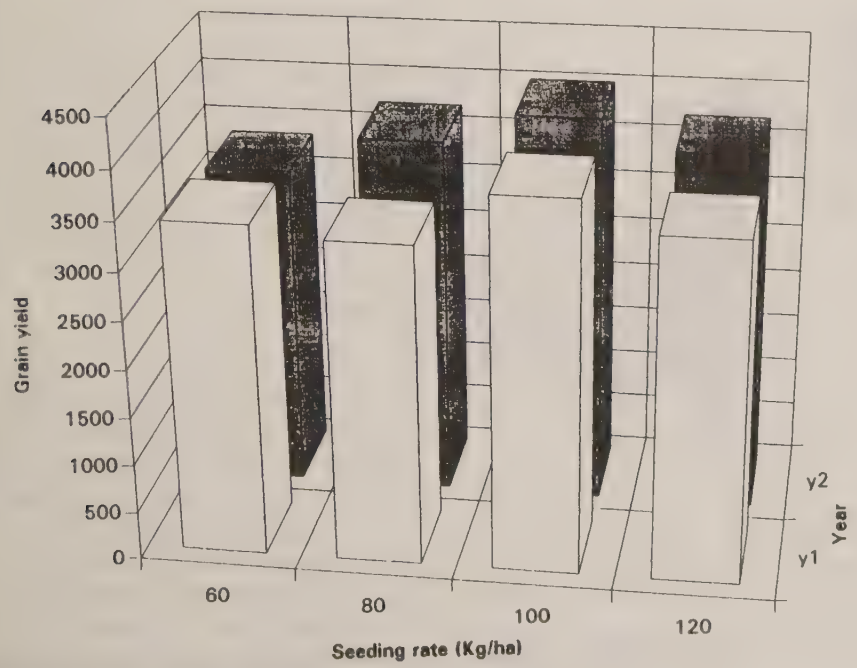

Fig. 2. Grain yield (kg/ha) of barley (cv. 'Rihane') at different seeding rates.

Tillage systems

In the SAR, a rotation of crop and fallow constitutes the major system for cereal production. The practice is controversial, mostly among professionals, because of the inefficiency in soil-water storage and the wind and water erosion associated with fallow. However, the crop-fallow system in the SAR continues to be used despite its critics. Conventional tillage practices include deep plowing in the fall of the fallow year followed by disking in early winter, if time and weather permit. The field is deep-plowed a second time in the spring, followed by two disking operations, one in the summer and one before planting.

Increased use of crop residues by means of stubble mulch tillage has alleviated some erosion problems and increased moisture storage. In Tunisia, this system cannot be implemented effectively because straw residues are used for livestock grazing and feed. Consequently, a reduced tillage system is used that allows grazing of straw in the summer and of weeds in the spring of the fallow year. Under this system, the number of tillage operations is reduced to a minimum. Sweep cultivators are used either in late spring following weed grazing instead of deep plowing, or in the fall before planting. One or two passages of tandem or offset disks prior to planting are recommended following sweep cultivation. Herbicides are used for weed control during the crop season. On-farm experiments have shown no significant difference in the yield of durum wheat under reduced tillage compared with traditional tillage (Fig. 4).

Weed Control and Fertilizer Application

Timely weed control, even under poor management, substantially increases yields (Hepworth et al., 1975). Proper chemical

Table 5. Grain yield (kg/ha) for durum wheat and barley with three row spacings.

	20 cm		30 cm		40 cm	
	1992	1993	1992	1993	1992	1993
Durum wheat	2713	2621	2652	2563	2527	2559
Barley	3469	3538	3834	3708	3584	3028

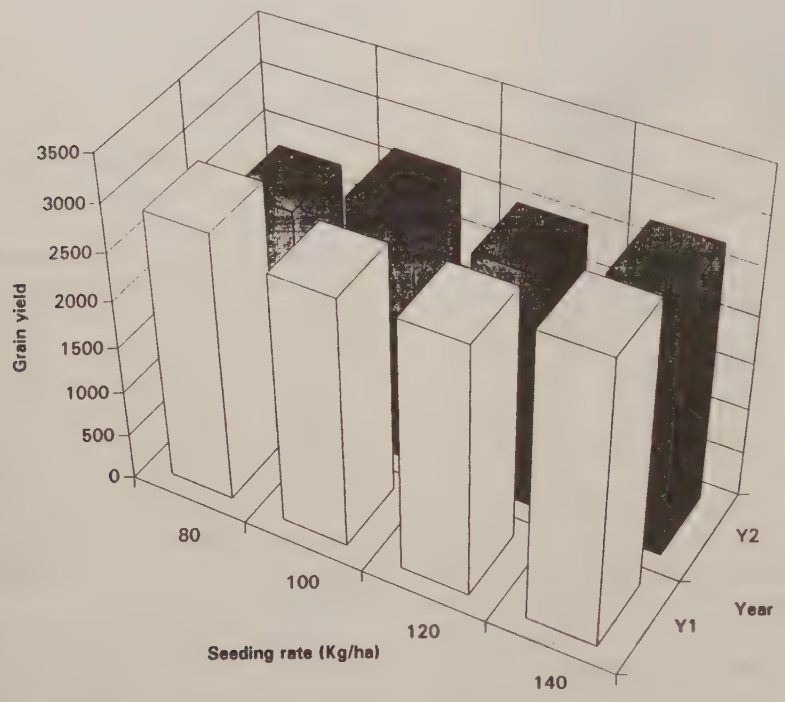

Fig. 3. Grain yield (kg/ha) of wheat (cv. 'Inrat 69') at four seeding rates.

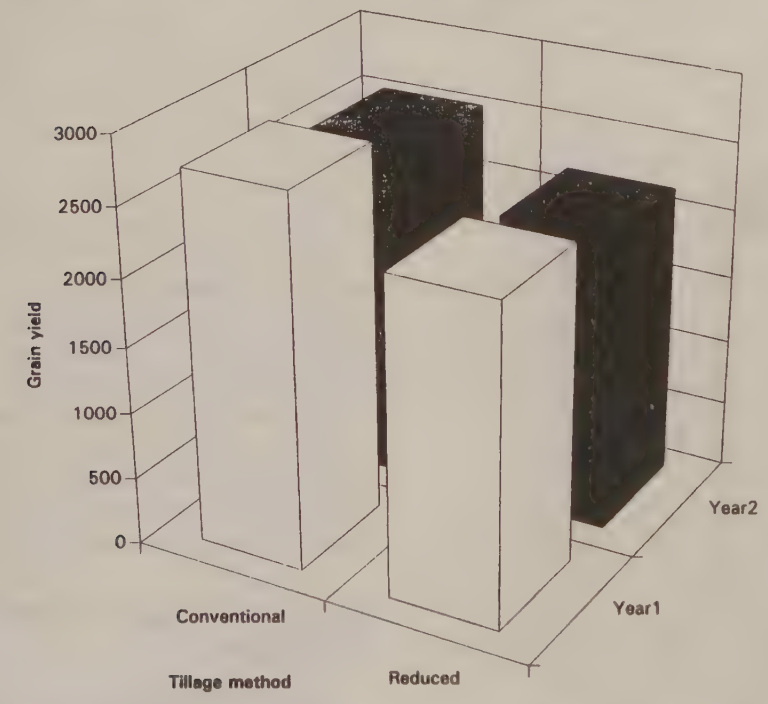

Fig. 4. Grain yield (kg/ha) of durum wheat under conventional and reduced tillage practices during a two-year study.

weed control increases yield of barley by up to 87% and durum wheat by 93% (Figs. 5 and 6). As weeds proliferate and persist, specific and polyvalent herbicides strengthen and add flexibility to a farmer's weed control program. An effective dryland weed control system in the SAR includes coordinated, integrated use of cultural practices and herbicides.

The cereal producing regions of Tunisia, particularly the SAR, have suffered soil erosion over the centuries. This is due in large part to the erosive nature of the environment, but it is aggravated by current soil and crop management practices. Improved surface cover during the crop year and greater surface residues during the fallow year would greatly reduce soil erosion. The recommended use of fertilizers could alleviate this problem because it is the most economical way of increasing crop production and therefore the amount of surface residue. Use of nitrogen fertilizer can more than double crop yields, particularly of durum wheat, and to a lesser extent increases barley yields (Figs. 5 and 6).

Weed control and fertilizer application are the determining factors for improving crop production. If fertilizers are introduced in the SAR as an improved practice and weeds are left uncontrolled, weeds may respond to the increased fertility level more than the crop does. In some cases this reduces yields, as shown in Figs. 5 and 6 for Tejrouine (Tejr.), where the check yield was higher than yields with fertilizer application. An appropriate combination of weed control and fertilizer provided the best results compared with either component alone or with the check. Increases of 129% and 90% for barley and wheat, respectively, have been observed with proper weed control and fertilizer application practices.

Conclusions

Sustainable rainfed crop production in the SAR has been most successful when the "package of practices" approach has been used. This approach uses the best combination of tillage for moisture conservation and seedbed preparation, selection of adapted varieties, optimum seeding rates, fertilizer applications, and timely weed control. Timing of each component is very important, and may vary from one region to another. Determining the best combination

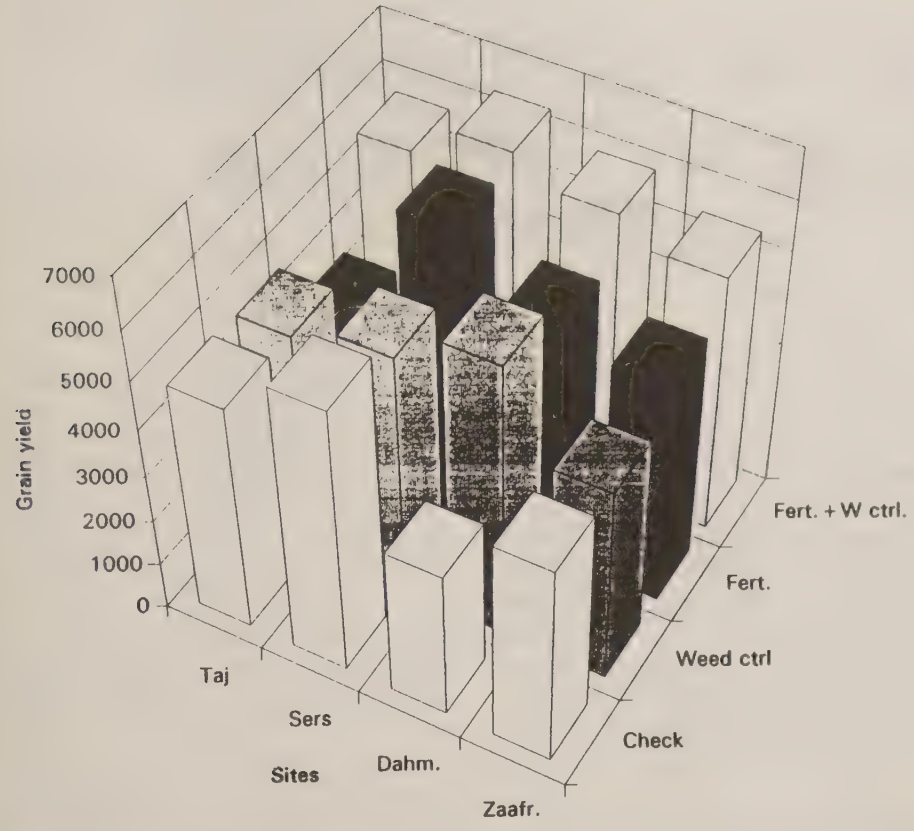

Fig. 5. Grain yield (kg/ha) of barley (cv. 'Rihane') under various fertilizer and weed control treatments.

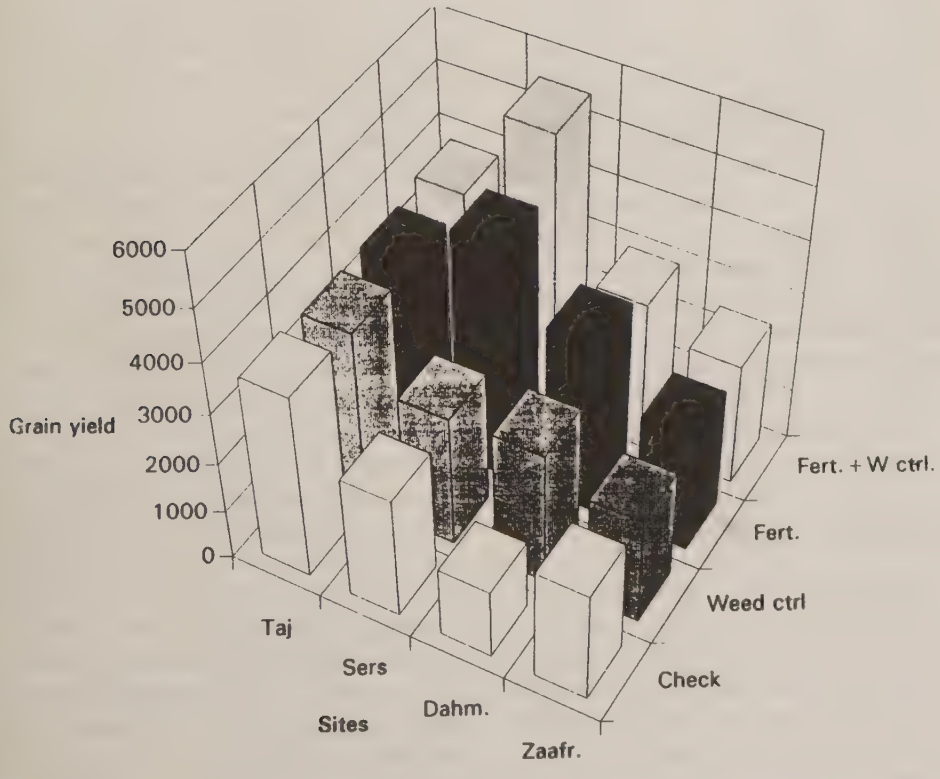

Fig. 6. Grain yield (kg/ha) of wheat (cv. 'Inrat 69') under various fertilizer and weed control treatments.

of practices requires extensive, applied field research conducted over a long time, particularly in the SAR.

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The potential for sustainable rainfed farming in Palestine

Jad Isaac and Stephen Gasteyer

Abstract. *The most important source of increased crop yield in the Middle East has probably been the increase in irrigated area although it has been accompanied by other inputs such as chemical fertilizers, improved varieties, mechanization, and pesticides. Palestine, which in this paper encompasses West Bank and Gaza, has had a similar emphasis on irrigation although only 5% of West Bank agricultural land is irrigated. However, the possibility of further expanding or even maintaining present water use for fostering agricultural growth in this dry region is diminishing. There now is a growing understanding that future sustainable agriculture in the Middle East may depend on shifting emphasis to rainfed farming; in the past, this was not considered possible because of its perceived low productive potential. Recent research, however, has evaluated the status of rainfed farming in Palestine and targeted areas that need improvement. Experiments and demonstrations have shown the potential to vastly improve rainfed farming's production, economic return and status. Following up on these initial steps should be an important priority in maintaining food production in this region.*

Key words: agricultural policy, agricultural marketing, dry farming, integrated systems, land use, on-farm research, sustainable agriculture, water availability, water use

Introduction

Since the 1950s, much of the progress in agricultural production in the Middle East has come through the introduction and expansion of irrigated agriculture. While agricultural production has risen, the input on which that production is based (water for irrigation) is now recognized as under threat (Allaya, 1994, p. 196). Rapidly growing populations are taxing the water resources already in use. Irrigation is often the major drain on water resources, accounting for 70% of total consumption.

Over the past 45 years, the mistaken idea has emerged from the post-World War II agricultural revolution that development of agriculture in the Middle East is not possible without irrigation. However, nonirrigated rainfed farming, the system that has existed possibly since the development of agriculture itself thousands of years ago, has almost been ignored. It is imperative for the agricultural establishment to return to rainfed agriculture as a system sustainable both culturally and ecologically. This paper assesses the status of rainfed agriculture in Palestine (defined here as the West Bank, including East Jerusalem, and Gaza), and demonstrates its significant potential.

Rainfed agriculture is already important here, making up 90% of the cultivated area in Palestine (95% in the West Bank, and 35% in Gaza), and the climate of large parts of the area is conducive for the its development (Table 1). It is important to distinguish, however, between the West Bank, where there are three regions with rainfed agricultural potential, and the Gaza Strip, where potential for nonirrigated farming is low.

Physical Characteristics

Despite its small size, Palestine enjoys a diversity of topographic and climatic conditions that offer great opportunity for agricultural variation and, to a limited extent, regional specialization (Fig. 1). Although it principally has a Mediterranean climate characterized by hot, dry summers and short, rainy winters, variations in altitude and latitude contribute elements of subtropical aridity. The West Bank can be divided into four distinct regions based on topography and climate variation (Figs. 1 and 2).

Table 1. Cultivated areas in Palestine (1000 ha).

	West Bank	Gaza Strip
Rainfed	18.78	0.56
Irrigated	1.04	1.09

The Jordan Valley Region consists of the West Bank of the Jordan River, comprising 40 thousand ha. Average elevation is between 200–300 m below sea level; the climate is semi-arid. Annual rainfall ranges from 100 mm in the South to 350 mm in the North. The soil in the northern part of the Valley is calcareous; the south is made up mostly of sand dunes. Vegetables and citrus are commonly planted under irrigated conditions.

Extending from Jenin in the North to the Dead Sea area, the Eastern Slopes Region has a total area of 150 thousand ha. Altitude ranges from –50 m to 800 m above sea level. This semi-arid, desertlike area is characterized by low rainfall (averaging 250 mm annually), steep mountains, and a thin topsoil, which render it suitable for grazing and the cultivation of drought-resistant field crops such as barley (Figs. 1 through 3).

The Central Highlands Region extends from western Jenin in the North to Hebron in the South. At 350 thousand ha, it is the largest region. Its altitude exceeds 1000 m above sea level. Its rainfall is more abundant, ranging from 400 mm to 700 mm annually. While olive plantations are numerous, the Central Highlands Region enjoys diversified production. However, soil erosion is of growing concern (Figs. 1 through 3).

In the northwest corner of the West Bank lies the Semi-Coastal Region, with an

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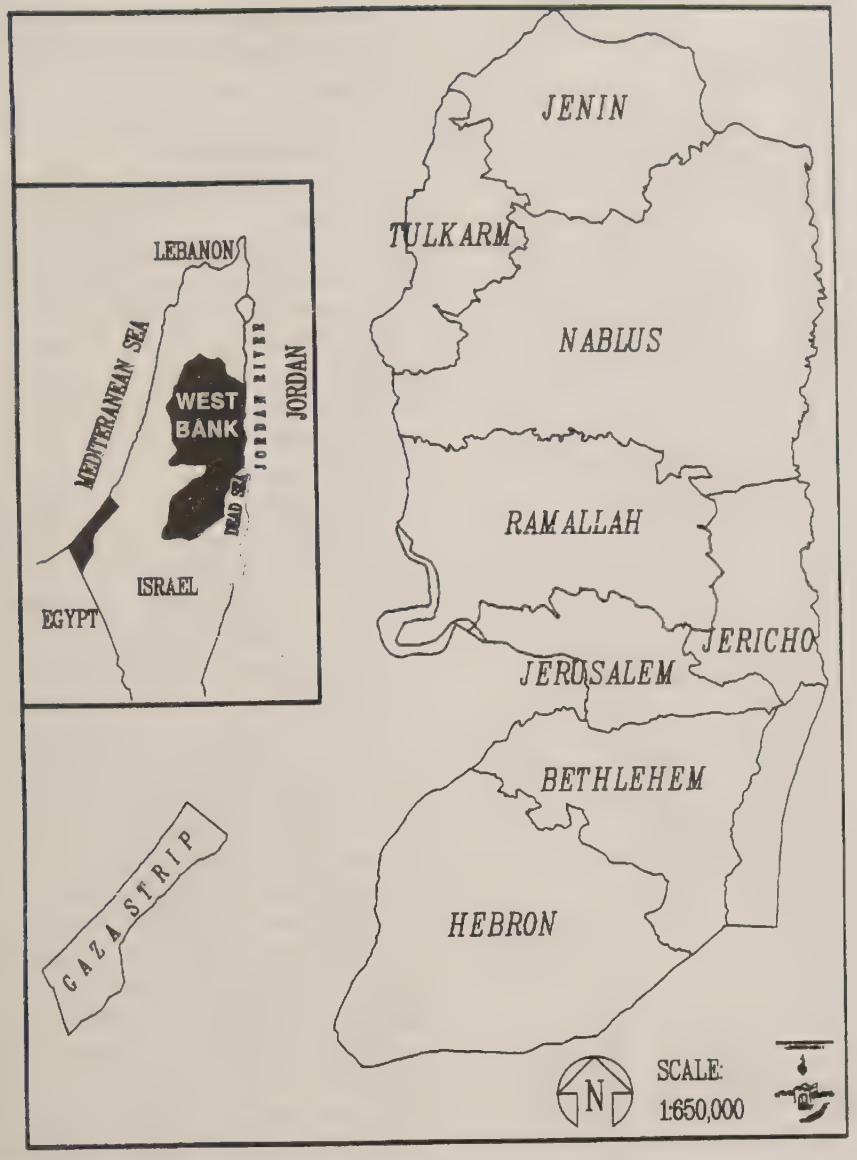


Figure 1. Districts of Palestine. Source: ARIJ, GIS Unit, 1994.

area of approximately 40 thousand ha. Elevation ranges from 100 m to 300 m above sea level and average annual rainfall varies between 400 mm and 600 mm. Terra-rosa and alluvial soils make this region suitable for field crops (Figs. 2 and 4).

Approximately 390 thousand ha receive between 400 mm and 700 mm of rain annually. However, this rainfall is concentrated, with around 79% coming in December through February (Figs. 3 and 5).

The watershed of the north-south mountain range represents a natural division between the more fertile western slopes and the semi-arid eastern slopes. The estimated average annual rainfall on the West Bank is about 2,000–3,000 million m^3. About 80% of it falls on the western slopes (ARIJ, 1994a pp. 1–3).

The Gaza Strip is naturally less fertile. An area of just 350 km^2, with mostly sandy loess soils and with rainfall between 200 mm and 400 mm annually, the potential for improving production in this area is limited. However, rainfed farming is still significant with 7.4 thousand ha in field crops and fruit trees out of a total cropped area of 18.8 thousand ha (ARIJ, 1994a, p. 3) (Table 1; Figs. 1 and 3).

Although these figures show the potential for the expansion of rainfed farming, agriculture is already an important part of the society and the economy. Making up about 25% of the Palestinian Gross National Product (GNP) and 29% of employment, agriculture will undoubtedly be an important engine of growth for the economy of the new Palestinian state. Furthermore, more than 55% of the population of the West Bank still lives in rural areas, and the fraction of the labor force working directly with agriculture may grow as Palestine is allowed to develop its own economy (Central Bureau of Statistics of Israel, 1993, pp. 756–790; UNCTAD, 1993, p. 9; Palestine Bureau of Statistics, 1994, pp. 127–142).

Why Not Irrigated Farming?

The quickest method of increasing income from agriculture in this climate would probably be the development of new irrigated areas. However, the possible short-term gains from this are far outweighed by their long-term environmental and planning consequences. Although Palestine and Israel both have some of the most efficient irrigation systems in the world, analysis of current available water sources, domestic consumption, and projected population growth in Israel and Palestine indicate that by early in the next century all currently available water sources will have to be devoted to domestic consumption (Boneh and Baida, 1977–1978; Schwarz, 1980; Tahal, 1990; Postel, 1992, p. 105; Al-Khatib et al., 1993).

Some water will be made available through improved water conservation and efficiency measures, such as water harvesting, wastewater use and cloud seeding, but this probably will be enough only to maintain the current levels of irrigation as increasing amounts of water (up to 70% more) will need to be devoted to domestic and industrial uses. Some say that future irrigation in Palestine and Israel will be possible only with wastewater (Ben-Meir, 1994, p. 33). The argument that we can count on technology and international water diversion schemes to create new water sources seems unrealistic. The economic and environmental soundness of schemes so far is at best questionable (Israel Environment Bulletin, 1995, p. 15).

Furthermore, disputes in the Middle East over water allocation already are a potential risk. It is hard to imagine how diverting other Middle East water would not exacerbate such disputes (Postel, 1992, pp. 73–74; Gleick, 1993, p. 9; Bingham et al., 1994, pp. 78–101).

Given this, it is prudent to assume that there is room for only limited expansion of

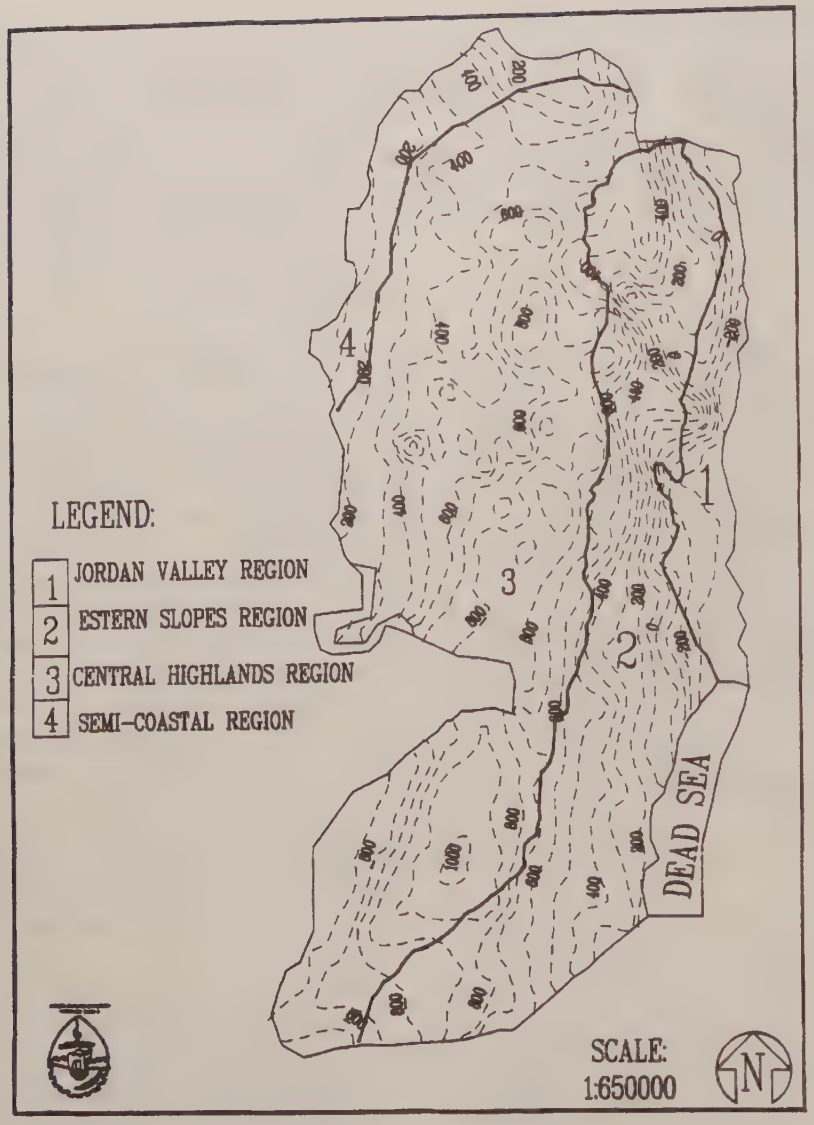


Figure 2. Eco-regional zones in the West Bank. Source: ARIJ (1994a).

the Palestinian area now under irrigated cultivation, even assuming that there will be significant decreases in Israeli irrigated area over time. Common sense and sound environmental thinking indicate that far more research is needed to enhance the potential of rainfed agriculture in this region.

Status of Rainfed Farming and the Major Crops in Palestine

In part because of the lack of attention to rainfed farming in the agricultural research and extension community, the region largely still uses traditional integrated farming systems, in which the farm family raises livestock, field crops and vegetables. While these systems have positive attributes, specifically their cultural and environmental sustainability, they tend to be far less productive and less economically profitable than irrigated agriculture. This has been exacerbated by the fact that the land held per farmer has decreased significantly since 1967, mostly because of population growth and traditional tenure arrangements. As a result, fewer than half of the holdings in the West Bank are more than 1 ha, fewer than one-fourth are more than 2 ha, and fewer than one-tenth are more than 5 ha (ARIJ, 1994a, p. 13) (Table 2).

Animal plows are still widely used in Palestinian agriculture, although mechanized agriculture is becoming more prominent in the production of field crops, especially in the northern plains and less mountainous regions. However, because of the small holdings and the topography, mechanized harvesters have only limited potential. As a result, harvest of fruit trees and field crops often is done manually. Most farms in the West Bank are involved in small-scale production of livestock, mostly chickens, sheep, and goats, along with crop production. Animal manure is widely used as fertilizer although chemical fertilizers are being introduced for both field crops and vegetables. Most weeding is done manually, although herbicides and other chemical weed control methods are a new and growing technology, especially in production of wheat (*Triticum aestivum* and *T. durum*). Farmers traditionally practice crop rotation with time allotted for fallowing when planting field crops, especially in regions with less than 300 mm annual precipitation (ARIJ, 1994a, pp. 13–15) (Figs. 1 through 3).

Rainfed agriculture in Palestine encompasses four major types of farming: cultivated field crops and forages, fruit trees, vegetables, and livestock (range management and pastures). The status and prospects for growth vary for each of these sectors and are outlined below (Fig. 2 and Table 3).

Field Crops and Forages

Field crops and forages cover 17.5% of agricultural land, and are mostly cereals

Table 2. Average farm size in Palestine (% in each rainfall zone).

	Rainfall (mm)					
Farm Size (ha)	**All**	**700**	**600**	**500**	**400**	**300**
<0.5	33.7	37.0	33.0	43.0	22.0	—
0.5–2.0	41.4	41.4	43.0	37.0	52.0	34.0
2.0–5.0	16.1	16.4	14.0	10.0	17.0	44.0
5.0–10.0	5.7	—	5.0	5.0	9.0	—
>10.0	3.1	3.6	5.0	5.0	—	22.0

Source: ARIJ (1994a, p. 14).

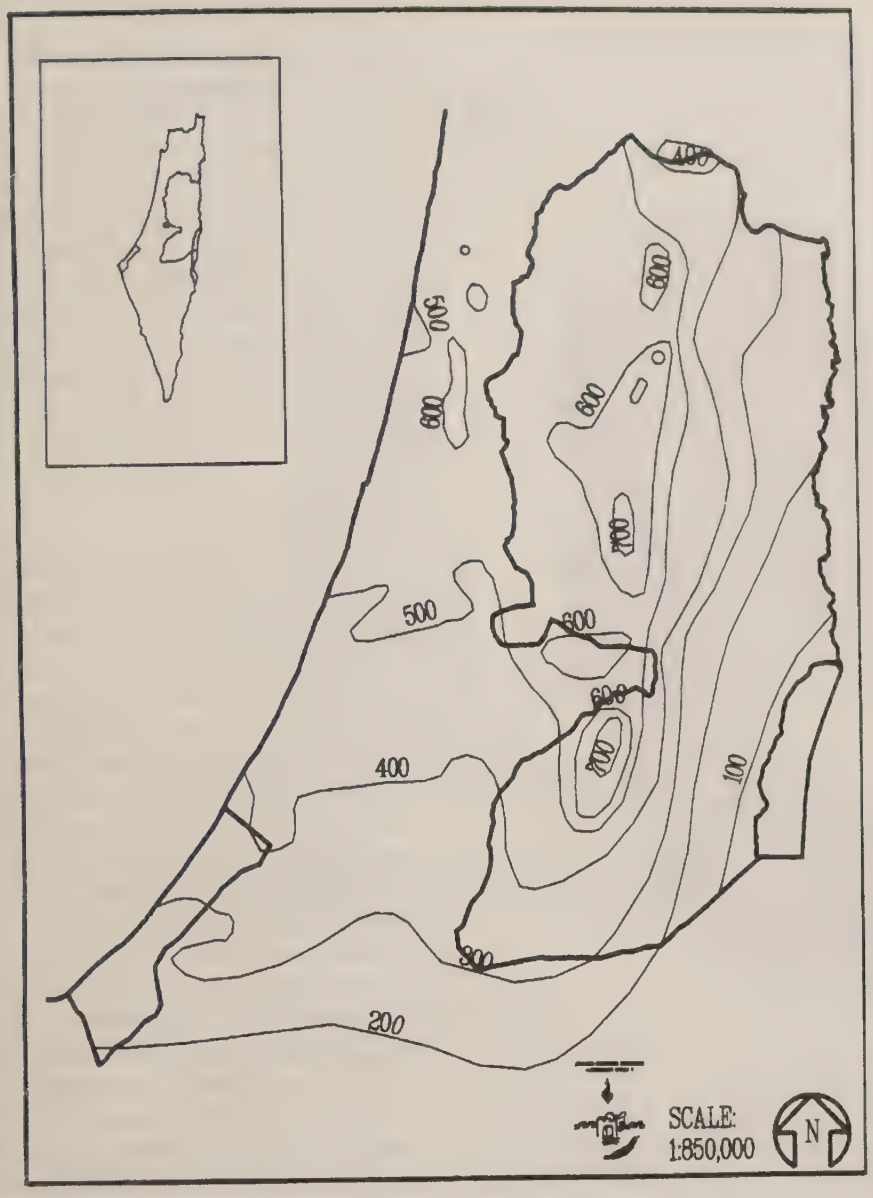


Figure 3. Generalized rainfall map for Palestine and central Israel.

Table 3. Area and production of major rainfed agriculture sectors.

	Area		Production	
	1,000 ha	%	1,000 t	%
Fruit trees	104.5	54.0	165.0	58.0
Cereals	33.9	17.5	61.2	21.5
Legumes	11.6	6.0	6.5	2.3
Vegetables	11.2	5.8	51.8	18.2
Fallow	32.3	16.7		

Source: ARIJ (1994a), except "Fallow," which is from Abu Arafeh et al. (1992, p. 31).

and legumes. The fact that this sector produces such a low fraction of total rainfed production indicates a major shortcoming of Palestinian agriculture. While Palestinian society is struggling not to become dependent on imports and oriented toward the service sector, the farming sector produces less than 16% of the consumption of wheat, 8% of chickpeas (*Cicer arietinum*) and 7% of lentils (*Lens culinaris*), the staples of the Palestinian diet. The low economic potential of these crops plays a role in this low productivity, with wheat, for example, currently averaging a net return of as low as $140/ha, depending on variety and inputs. A related problem is that local varieties have low production potential, a problem compounded by low and sporadic rainfall, unsophisticated cultivation practices, inadequate pest and disease control, and inadequate use of fertilizers (ARIJ, 1994a, p. 36).

Cereals

Among field crops, cereals have the highest area under cultivation in the Palestinian Territories, covering almost 40 thousand ha. Wheat is the most important, covering an average area of more than 19.5 thousand ha, or 50.4% of the total area devoted to field crops. Wheat is followed by barley (*Hordeum vulgare*), covering more than 17 thousand ha (44.4%), and sorghum (*Sorghum bicolor* and *S. vulgare*), covering just over 2 thousand ha (5.2%) (ARIJ, 1994a, p. 36).

Legumes

Legumes are an important part of both the human diet and forage for animals. Of the food legumes, chickpea and lentil are by far the most cultivated, with broad beans (*Vicia faba*), pea (*Phaseolus vulgaris*), soybean (*Glycine max*), cowpea (*Vigna sinensis*) and peanut (*Arachis hypogaea*) cultivated least. Over the past 10 years, the average area of chickpea cultivation in Palestine has fluctuated between 2.5 and 4.2 thousand ha throughout the West Bank, with about 85% of that production taking place in the northern regions (mostly in Jenin). Average yield is only 650 kg/ha, and annual maximum production is only between 1.6 and 2.7 thousand tons. The area cultivated with lentils has varied during this period between 3.1 and 4.5 thousand ha, with yield reaching 450 kg/ha. The most productive regions, however, have been Jenin and Hebron (Fig. 1).

Vetch, used mostly as fodder for animals, is the other major rainfed cultivated legume, with an average area of production of 5.2 thousand ha. Bitter vetch (*Vicia ervilia*) accounts for 77% of the area planted to vetch, common vetch (*V. sativa*) the rest; their average yields are 550 and 650 kg/ha, respectively. Production has risen in recent years as demand has increased for animal feed

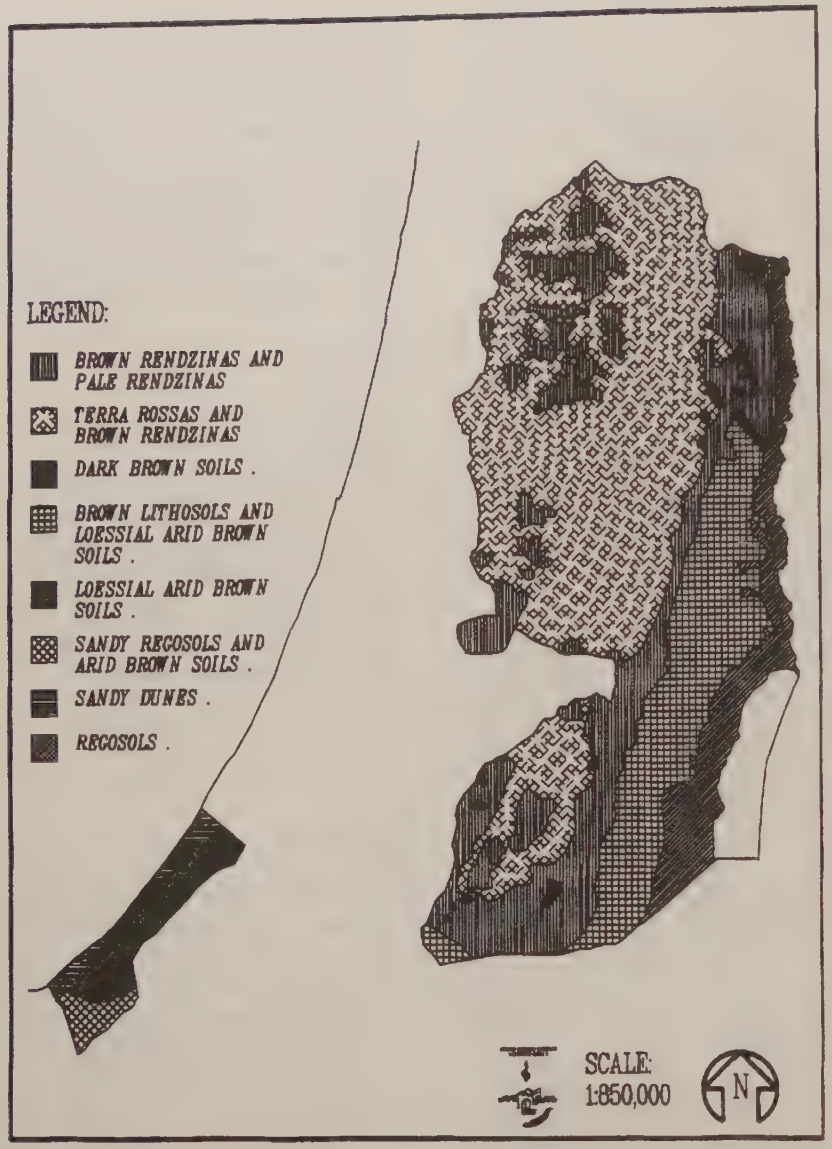


Figure 4. Soil map of Palestine. Source: Survey of Israel (1994).

because of overgrazing on the available pastureland (Rural Research Center, 1985–90; ARIJ, 1994a, p. 52).

Fruit

Fruit trees are not just a source of food and economic livelihood for Palestinians but also an important part of the culture. They are planted throughout Palestine, especially the West Bank, making up 54% of the total cultivated area and 58% of total production.

Olive

Olive (*Olea europaea*) is the most widely planted crop, representing an important part of Palestinian culture and an economic base for many rural Palestinians. The olive tree is often used as a symbol of the millennium-long attachment to the land (indeed, olive trees can live hundreds, if not thousands, of years). Yet it is precisely for this reason that olive production is low, as farmers often plant olives simply to hold land, and thus are lax in maintenance. Only three varieties are planted here, sorri, local nabali, and baladi (indigenous stock), and all three are considered better for oil than fruit production. Another quirk of olive production here is the "alternate bearing" phenomenon, with production heavy during one year and almost nonexistent the next. In Israel this phenomenon has been combatted by using irrigation to regulate water intake throughout the year, a practical impossibility given current water constraints described above (ARIJ, 1994a, p. 65) (Table 2).

Stone fruits

Other stone fruits have more potential for development because of their marketability. After olives, almond (*Prunus amygdalus*) is the second most widely planted crop; most of the dozen or so varieties grown here are indigenous. They need a fairly deep soil, as do most stone fruits, but otherwise are well adapted to local conditions. However, almond production is quite low, averaging around 500 kg/ha under rainfed conditions, largely because many orchards are not maintained.

Production is better for plums (*Prunus domestica* and *P. salicina*), peaches (*P. persica*) and apricots (*P. armeniaca*), all of which are planted for their marketability. Of the three, plums and apricots are produced in surplus and peaches are underproduced. The surplus is easily absorbed (mostly by neighboring Israel); thus, production could be improved without major marketing problems (ARIJ, 1994a, pp. 87–96) (Tables 4–7; Fig. 4).

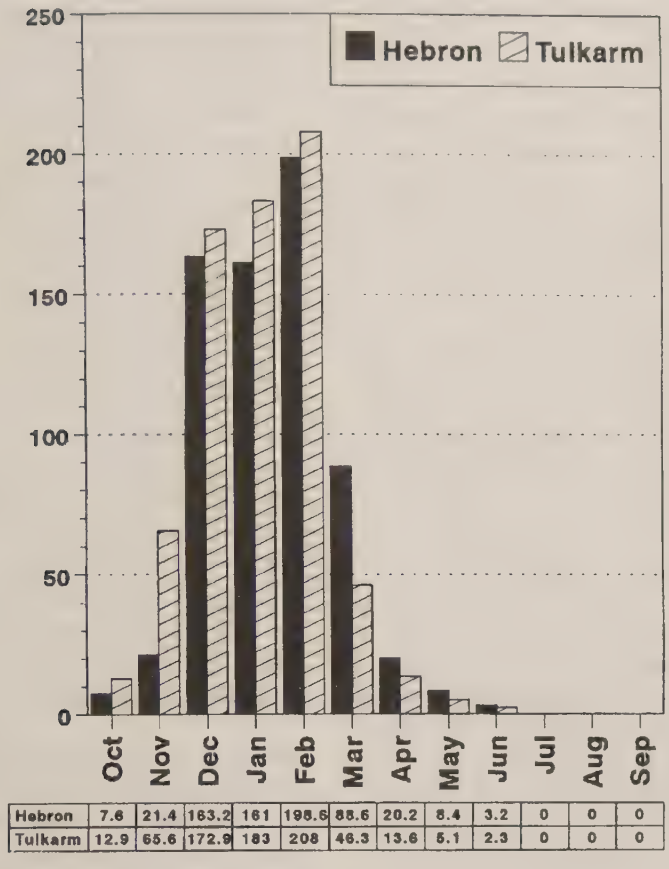
Grapes

Although grown throughout Palestine, grapes (*Vitis vinifera*) are especially important in Hebron, where they take up 5.1

Table 4. Average olive yield in Palestine (kg/ha).

Year	Hebron	Jenin	Nablus	Ramallah & Bethlehem	Tulkarem	Gaza[1]
1989	220	110	90	90	90	2000
1990	2000	2100	1800	1800	2000	3000
1991	250	60	50	30	250	4000
1992	2700	2600	2270	2080	2090	5000

[1] under irrigation
Source: ARIJ (1994a, p.66).



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Hebron	7.6	21.4	163.2	161	198.6	88.6	20.2	8.4	3.2	0	0	0
Tulkarm	12.9	65.6	172.9	183	208	46.3	13.6	5.1	2.3	0	0	0

Average total for Hebron = 672 mm.
Average total for Tulkarem = 710 mm.

Figure 5. Distribution of monthly rainfall at Tulkarm and Hebron Districts, 1989/90 to 1991/92 (mm).

thousand ha and are a vital part of the rural economy. Grapes have been produced in this area for centuries. White, black and red berry varieties are well adapted to local conditions, although farmers have had trouble introducing seedless varieties under rainfed conditions. They grow well in deep soils with good waterholding capacity, and can withstand different levels of salinity, depending on the variety. However, they also are very sensitive to soil nutrient deficiencies which may be hampering production and exacerbating diseases such as powdery mildew (caused by *Uncinula necator*), a chronic problem. Attempts to control this and other grape pests with chemicals have caused grape farmers to use pesticides that are banned internationally, which clearly has both health and marketing implications. Furthermore, production exceeds demand during the period when grapes are produced most heavily since up to 80% of the grapes ripen between August and November (ARIJ, 1994a, pp. 79–86; 1994b).

Figs

Fig (*Ficus carica*) also has traditionally been grown here. It is easily propagated and adapts well to the prevailing climate. Although figs are highly nutritional, production is low (10 thousand tons produced on 2.3 thousand ha) not only because of poor marketing and processing infrastructure but also because of chronic pest problems, including fig scale (*Lepidosaphes conchiformis*), mite (*Tetranychus urticae*), endosepsis caused by the fungus *Fusarium moniliforme*, and fig mosaic virus, all of which afflict the 19 most produced varieties (ARIJ, 1994a, pp. 92–102).

Rainfed Vegetables

While most production of vegetable crops must come from irrigated farming, specifically in Gaza, Jericho, Tulkarem and Jenin, rainfed farming is responsible for some 70% of their cultivated area in Palestine as a whole, and 18.2% of total rainfed agricultural production. Eleven major vegetable crops are produced under rainfed conditions. In the Gaza Strip the most important cultivated vegetables are watermelon, muskmelon, okra, snake cucumber and tomatoes. In the West Bank the most important vegetable crops are, in order: tomato, dry bulb onion, squash, okra, and snake cucumber. These are planted in two seasons: dry bulb onion, cauliflower, garlic, potato, and green broad beans are planted in the early winter season (October, November); crops such as tomato, squash, okra, snake cucumber, watermelon, and

Table 5. Expenses and returns of stone fruits in Palestine.

	Expenses ($/ha)						Returns ($/ha)	
Type	Tillage	Fertilizer & Pesticide	Pruning & Picking	Total	Yield (kg/ha)	Price ($/kg)	Total	Net
Apricots	20	20	20	60	5300	1.00	5300	4700
Plums	20	20	20	60	3900	0.74	2890	2290
Peaches	20	20	20	60	4500	0.34	1530	930
Almonds	10	—	10	20	450	1.00	450	250

Source: ARIJ (1994a, p. 96).

Table 6. Stone fruit production and consumption in Palestine, 1991–1992 (tons)

Type	Production	Consumption	Surplus
Almonds	4,503	1,200	3,303
Plums	13,859	7,400	6,459
Apricots	2,651	2,280	371
Peaches	356	15,800	–15,444
Total	21,369	26,680	–5,311

Source: ARIJ (1994a, p. 87).

cantaloupe are planted in the spring when the weather is turning warm but water remains in the soil. Because they are exposed to limiting environmental factors, rainfed vegetables are not nearly as consistent and, therefore, not as marketable as those grown under irrigation. Largely for this reason, they also are grown with far fewer inputs so that production is much lower. The development potential for rainfed vegetables is generally believed to be very low. More research is still needed to assess this sector's potential feasibility, specifically since local landraces may include gene stock resistant to drought and disease (ARIJ, 1994a, pp. 103–107).

Rangeland and Natural Pastures

Natural pastures clearly are very important for livestock production, which currently provides close to 40% of the agricultural GDP in Palestine and is an important part of the traditional agricultural system. Unfortunately, because of land shortages from livestock and population growth and from continuing restrictions on land use due to the ongoing Palestinian-Israeli conflict, and because of the degradation of pastureland that has accompanied these trends, herders increasingly are forced to substitute forage for grazing. This has raised the price of forage significantly. Most forage is said to be imported, indicating a significant market for it (ARIJ, 1994a, pp. 108–119).

Pesticides

The development of agriculture here since World War II, as in other parts of the world, in large part has been fueled by agricultural chemicals. Globally and in Palestine, the agricultural establishment is beginning to look for alternatives as the harmful side effects on human health and the environment become more apparent.

However, as in many developing countries, the chemicals to which Palestinian farmers have access rank among the most dangerous, with fourteen of the most used pesticides internationally suspended or banned and seven listed on the "dirty dozen" list of pesticides that are particularly harmful environmentally. Most pesticides are used on irrigated crops, with 56% applied to the 5% of arable land on the West Bank that is irrigated (Saleh et al., 1995, pp. 3,6).

However, chemicals also are used in the rainfed areas, specifically to treat fruit trees and grapes. While this use currently is low, it no doubt would increase if agricultural production became more profitable in these areas (Saleh et al., 1995, Annex 2).

Programs encouraging integrated pest management (IPM) need to be implemented. Several organizations are involved in developing IPM programs in the West Bank and Gaza. However, much more needs to be done to encourage and implement programs to address this important issue. There have been significant advances in the development of biocontrol agents and other kinds of pest control that are not harmful to human health or the environment. Significant effort is needed to make these available to Palestinian farmers and to develop standards, regulations and delivery systems that phase out the dangerous chemicals currently in use (Sansur, 1992).

The Potential for Sustainable Rainfed Agriculture

Although rainfed agriculture has great potential, it has not prospered here in the past 30 years. The reasons for this are in part the inherent risks that farming entails, including the inadequacy and unpredictability of rainfall and the risk of losing the whole crop to excessive heat, insect pests or diseases. However, sociopolitical factors such as loss of land to Israeli control, the division of land into small parcels because of the traditional tenure and inheritance systems, and the departure of rural people from their lands to seek better-paying work in Israel have also played a role

This phenomenon has decreased agricultural output considerably. For instance, the area in wheat on the West Bank has decreased from 46.2 thousand ha in the 1960s

Table 7. Average yields, cultivated area, and total production of field crops and stone fruits in Hebron.

Crop	Yield (kg/ha)				Production (tons)[1]	
	Demonstration	Local Average	Demon./ Local Av.	Cultivated Area (ha)	Demonstration	Local Average
Wheat	2,400	820	2.9	4,770	11,448	3,911
Sorghum	930	690	1.5	269	250	158
Chickpeas	1,060	560	1.9	319	338	179
Plums	10,330	4,000	2.6	1,303	13,455	5,210
Apricots	10,000	3,500	2.9	34	337	118

[1]Production from indicated cultivated area assuming demonstration or local average yield, respectively. Source: Hrimat (1995).

to 17 thousand ha in the 1990s. Furthermore, the average productivity of different rainfed crops in Palestine is very low, despite the high rainfall in some regions. Studying ways to increase productivity, therefore, is essential for improving this sector (Isaac and Hrimat, 1995).

To reverse the decline in production and to overcome the obstacles that hinder rainfed agriculture in Palestine, research must be focused on developing practical solutions to problems in all aspects of rainfed agricultural cultivation including: introducing well-acclimatized crop varieties with high yield potential, increasing soil fertility, improving weed and insect pest control, introducing mechanization, shifting planting dates, implementing and improving crop rotations, and improving the research and extension system. All this should be done through supporting and working in cooperation with the farmers. Below are examples of such work that have been carried out so far in Palestine.

Efforts to increase production in rainfed farming have shown some success in both demonstrations and experiments conducted by the Applied Research Institute-Jerusalem (ARIJ) and in government-supported experiments at Al-Aroub Agricultural Station, Hebron district. ARIJ worked with farmers at Al-Thahiriya, Hebron, to introduce new agricultural techniques and varieties in demonstrations on field crops. Al-Aroub has carried out experiments on improving yields of tree fruits for several years. The results in both cases have compared positively to the average production from local varieties using traditional methods (Hrimat and Isaac, 1995; Isaac and Hrimat, 1995) (Tables 8 and 9).

The demonstrations on wheat for 1992–93 and 1993–94 in Al-Thahiriya show the improvements in grain yield from integrated development of agricultural practices. ARIJ worked with farmers on the following simultaneous goals: to introduce new adapted wheat varieties, to improve land preparation through contour plowing and other methods, to improve soil fertility through crop rotation and the use of starter and top-dressed fertilizer, and to improve both manual and chemical weed control. All were important in increasing the yield.

The ARIJ wheat experiments and demonstrations had three components: the effects of introducing new adapted varieties, the effects of increasing soil fertility through fertilization, and the difference between bread wheat and durum wheat varieties. The introduction of new, adapted varieties increased grain production by 980 to 1,820 kg/ha over the average for local varieties. Farmers in Palestine traditionally add manure to the soil just before planting. The addition of compound fertilizer (13-7-0) at 500 kg/ha as essential fertilizer and ammonium sulfate (21%N) at 200 kg/ha as top dressing increased yield considerably. In the demonstrations, yields with fertilization ranged from 121% (for the local wheat variety) to 18% (for the Hazera Breket adapted variety) higher than without fertilization for the same variety. Bread wheat varieties tended to produce more than durum wheat varieties, with an average fertilized production of 2,445 kg/ha compared with 1,760 kg/ha. The combination of new varieties and improved fertilization showed potential to improve wheat grain yield by as much as 198% (Isaac and Hrimat, 1995) (Tables 8, 9).

Table 8. Yield and rainfall per unit yield in the ARIJ demonstration areas compared with the local average in Hebron.

		Yield (kg/ha)		Rainfall/Yield (m^3/kg)	
	Average rainfall (mm)	Demonstration	Local Average	Demonstration	Local Average
Wheat	276	2400	820	1.15	3.37
Sorghum	239	930	690	2.57	3.46
Chickpeas	314	1060	560	2.96	5.61
Plums	436	10330	4000	0.42	1.09
Apricots	436	10000	3500	0.44	1.25

Source: Hrimat (1995).

These results show that the risk in cultivation can be reduced when varieties with drought resistance and high growth rates are used so that the plants complete their growth cycle within a shorter period and before the danger of high temperature and water stress. Furthermore, improved yield increases water use efficiency by reducing the amount of water (rainfall) needed per unit area and per unit of production. In Al-Thahiriya, producing 1 kg of grain with the new wheat variety required 1.2 m^3 of water, conserving 2.2 m^3 compared with the local variety while increasing productivity. This could be very important in attacking the growing problem of desertification by bringing more land into sustainable production (Hrimat, 1995) (Table 9).

The effects on food self-sufficiency also could be significant. Hebron currently consumes an estimated 32.7 thousand tons of wheat annually. It currently produces an average of only about 3.9 thousand tons, or just 12% of consumption. Just the addition of fertilizer to the local variety increased production, even in the drought year of 1993–1994. If fertilization were carried out throughout Hebron, the region's farmers would produce 21% of the wheat consumed. The new, adapted grain varieties, if planted with fertilization throughout the region, would produce between 26% and 38% of consumption. More research is needed to determine the longer-term trends in yields and other characteristics in the Hebron region and to determine the adaptability of these varieties and techniques in other parts of Palestine (ARIJ, 1994a, pp. 41–42; Hrimat, 1995; Isaac and Hrimat, 1995) (Table 9).

Farmers often plant sorghum in the south of Hebron in late spring (March through May) as a fodder for their animals. This is increasingly important as available pastureland is deteriorating from overgrazing. However, the traditional varieties suffer significant damage from birds that eat the grain (ARIJ, 1994a, pp. 41–42; Hrimat, 1995).

Experiments were done using new high-yielding, bird-resistant varieties of sorghum in the 1993–94 growing season. Unfortunately this was a drought season, and the productivity of both local and improved sorghum decreased. However, the introduced variety in the end proved to be highly adaptable, faring much better than the local variety, which produced an economically negligible yield because of attacks by birds.

Table 9. Comparison of fertilized and unfertilized durum wheat and bread wheat varieties, Al-Thahiriya demonstration, Hebron.

Variety	Area (ha)	Production (kg)		Yield (kg/ha)		Yield Increase (%)	
		Grain	Straw	Grain	Straw	Grain	Straw
Durum wheat							
'870'							
fertilized	0.35	6,870	10,880	1,960	3,110	21.0	22.4
unfertilized	0.07	1,130	1,780	1,620	2,540		
'Breket'							
fertilized	0.26	4,680	8,740	1,800	3,360	18.4	15.9
unfertilized	0.10	1,520	2,900	1,520	2,900		
Local							
fertilized	0.20	2,920	4,280	1,460	2,140	121.2	89.4
unfertilized	0.07	460	790	660	1,130		
Bread Wheat							
'Attir'							
fertilized	0.18	4,750	6,550	2,640	3,640	53.5	48.6
unfertilized	0.04	690	980	1,720	2,450		
'Shaffir'							
fertilized	0.36	9,180	17,030	2,550	4,730	39.3	94.6
unfertilized	0.03	550	730	1,830	2,430		
'Beth Hashita'							
fertilized	0.26	5,850	10,500	2,250	4,040	38.9	67.6
unfertilized	0.09	1,460	2,170	1,620	2,410		
Total							
fertilized	1.60	34,250	57,980				
unfertilized	0.40	5,810	9,350				

Source: Isaac and Hrimat(1995).

Planted with greater care to soil fertility and soil water level, the bird-resistant sorghum produced a grain yield above 930 kg/ha. This exceeded the local average by 240 kg/ha, providing additional income and feed for the farmers (Hrimat, 1995).

Chickpea also showed good potential for increasing grain yield in response to improved agricultural practices and new high--yielding varieties resistant to *ascochyta* blight. Traditionally, chickpea is planted as a spring rather than winter crop because of fear of *ascochyta* blight, which tends to attack it in winter. This reduces water use efficiency because of lateness of sowing and makes the plants more sensitive to weather, thus reducing yield. By introducing resistant varieties, the planting date easily could be shifted to fall or early winter. ARIJ introduced *ascochyta*-resistant chickpea varieties, which were sown in early winter of 1993/94 in Al-Thahiriya. They yielded 500 kg/ha more than the local average in Hebron (ARIJ, 1994a, pp. 53–56; 1994b) (Table 7).

While these initial results are good, all these varieties are from Israeli companies, in particular 'Hazera'. Because of import restrictions, Palestinians have so far been unable to secure significant quantities of seeds from outside Israel, including from the International Agricultural Research Centers, specifically the International Center for Agricultural Research in Dry Areas (ICARDA) and the International Center for Research in the Semi-Arid Tropics (ICRISAT). These centers have produced varieties that might be highly adaptable to this environment. Furthermore, seeds for crops such as barley and lentils, which are not available through the Israeli seed companies, are available through these centers and would be very useful in improving the sustainability of agriculture in Palestine.

All these crops are field crops, not horticultural crops. However, the methods described above could easily be applied to increasing the productivity of rainfed fruit trees, vegetables, and grapes. For example, the results from the Al-Aroub agricultural research station showed that plum and apricot trees respond well to agricultural practices such as use of shallow harrows to avoid root system damage, improved soil fertility through fertilization, improved pest and weed control, and suitable application of a pruning, training system. This resulted in high productivity even in the drought year 1993–94, producing 6,330 kg/ha more plums (an increase of 260%) and 6,500 kg/ha more apricots (an increase of 290%) than the local averages (Hrimat, 1995; ARIJ, 1994a, pp. 60–62).

For crops such as grapes and figs, applied research is needed that targets new varieties, better pest control, improved soil fertility, and water conservation through mulching and soil texture improvement. More work also is needed in processing and marketing all these crops.

The potential economic payoffs of simply boosting yields should be noted, because one of rainfed agriculture's major impediments, especially in field crops, is the low economic return per hectare. In the 1993-1994 season, the introduction of new adapted varieties with fertilization earned as much as $517/ha in net revenue. Because of drought, the local variety yielded a net loss in the same year. A similar calculation could be made for plums and apricots, though the current net surplus of produce means that exact estimates of increased earnings are difficult to compute (Tables 6 and 7).

Conclusions

These results show that it is possible to increase agricultural production significantly in Palestine without depleting water resources through irrigation. Certainly, irrigation will remain important, and serious work will be needed to develop techniques for agricultural water conservation, reuse, and increased efficiency. However, it will be very important to develop the rainfed production sector and improve its efficiency and production potential. We have described the beginning of this process. Throughout the agricultural sector, more effort will be needed to develop environmentally friendly methods for fertilization and control of insects, weeds, and other pests, and to ensure that they are accessible to the farmer. These efforts must be integrated, combining agricultural marketing, natural science and social science considerations. Contact with the international agricultural research community, both governmental and nongovernmental, will be essential in bringing this about. The first steps have been made, but a long road lies ahead.

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USDA Creates New Office of Pest Management

The USDA has announced the creation of an Office of Pest Management that will serve as the agency's focal point for pesticide regulatory issues, and part of a new approach to minor use pesticides for the USDA and the EPA. The new office is charged with integrating and coordinating pesticide issues within the USDA, along with improving communications with and strengthening the existing network of grower organizations and crop specialists at land grant institutions. The agency can now be more responsive to the agricultural community in developing alternative pest management practices to meet critical needs that develop as a result of the regulatory process, according to Deputy Agriculture Secretary Richard Rominger.

Agricultural development in Israel: Challenges and opportunities for regional collaboration

No'am G. Seligman, Abraham Blum, Joseph Morin, and Jacob Amir

Abstract. *Agriculture in Israel is practiced throughout the country from the Arava Valley in the South, where average annual rainfall is less than 40 mm, to the Upper Galilee in the North, where annual rainfall exceeds 700 mm. Less than half the cultivated area used for field crops is irrigated. Much of the output is exported, primarily to Europe, but some to the United States and Japan. In nonirrigated dry-farming areas, the main crops grown are wheat for grain and silage and several secondary crops, including sunflower, watermelons and hay legumes. Animal production is predominantly intensive dairying (mainly cows, but also sheep and goats), poultry production, and aquaculture, all of which use large quantities of imported feed grains. Beef production is largely from dairy bullocks, but includes an important rangeland beef sector. Problems that face Israeli agriculture in general and dryland agriculture in particular are primarily economic, including low prices for many traditional dryland crops, a small local market, and increasing input costs. The changing socioeconomic scene, reflected by decreasing employment in agriculture, has added to the problems of proper land use. There is an urgent need for more appropriate production systems and associated innovative research and development. This includes management for higher output/input ratios, conservation and enhancement of genetic resources, crop diversification, integration of crop and livestock production, and alternative land use options such as agroforestry, recreation, ecological refuges, and landscape enhancement. These challenges are common to most countries in the Middle East, and offer opportunities for regional and international collaboration to improve the sustainability of agriculture in the region.*

Key words: dryland agriculture, Middle East, wheat, soil conservation, water conservation, agricultural research

Introduction

Conservation tillage and other aspects of sustainability bring to mind the following passage in Gen. 2:15:

> *And the Lord God took man and put him in the garden of Eden to dress it and to keep it* (King James Version)
>
> *. . . to till it and to keep it* (Revised American Version)
>
> *. . . to till it and to care for it* (New English Bible)

The translators all had difficulty in finding the precise agricultural terms for the original Hebrew *le'avda u-le'shamra*, which means "to cultivate it and to conserve it." On this evidence conservation, cultivation, and sustainability are old ideas, but the Bible has left us to work out all the many technical, logistic and socioeconomic details. Unravelling these complexities is a continuing challenge to all who till the land and to those of us who try to understand its nature. In Israel, we, too, must face this challenge, and as in so many other parts of the world we are meeting it with varying success. The successes and the failures provide fertile ground for collaborative research and development in the Middle East (Alberda et al., 1992).

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The Israeli Agricultural Scene

Israel is part of the "Fertile Crescent," where agriculture began and where animals were first domesticated. Agricultural practice over the ages has varied with the vagaries of climate, history, and economics, and over millennia "sustainability" has depended on constantly changing land use and production technologies (Even-Ari et al., 1971; Noy-Meir and Seligman, 1979). Today, agricultural production in Israel is practiced throughout the country from the Arava Valley in the South to the Galilee in the North. Rainfall varies from an annual average of 40 mm in the southern desert to over 700 mm in the North. The cultivated area in 1990 was 437 thousand ha, or 21% of the country. The remaining land is urban, rangeland, forests, natural reserves, lakes, and deserts (Table 1). Less than 4% of the population is actively engaged in agriculture, and many have supplementary income from nonagricultural activities. As is true around the world, the proportion of the population engaged in agriculture has been decreasing, while the scale and volume of agriculture has been increasing. Today, agriculture in Israel accounts for just under 3% of the gross national product.

Table 1. Land use in Israel (%).

Cultivated	21
Range, nature reserves, etc.	36
Afforestation	6
Desert	30
Urban, lakes, etc.	7

Slightly less that 40% of the cultivated area is irrigated. Irrigated crops include cotton (*Gossypium* spp.), corn (*Zea mays*) for silage, citrus, avocados (*Persea americana*), stone fruits, subtropical fruits, grapes (*Vitis* spp.), potatoes (*Solanum tuberosum*), groundnuts, melons, vegetables, and cut flowers. Much of this produce is exported, primarily to Europe, but also to the United States and to Japan. This sector includes a wide range of protected agriculture systems, from plastic tunnels to capital-intensive climate-controlled greenhouses.

Animal production is concentrated in intensive dairying (mainly cows, but also some sheep and goats) and poultry production. The Israeli-Friesian cow has an established reputation for record milk production, and the Assaf sheep breed (Awassi × East Friesian) has replaced the local Awassi as a dual-purpose intensive milk and meat breed. Recent work on incorporating the Booroola gene for high fecundity in local breeds promises more efficient sheep production. These intensive meat and milk production sectors, as well as aquaculture (carp, trout, and tilapia), saturate the local market by using large amounts of imported feed grains.

Beef is produced largely from dairy herds, but there also is an important rangeland beef sector. About two-thirds of the red meat consumed in the country is imported. Small ruminants, mostly sheep, are raised intensively both for milk and for fat lamb production. There also is an extensively managed sheep sector, mainly for meat production, based on rangeland and crop residues with supplementary feed given during part of the year.

The value of agricultural production in 1991 was $2.7 billion, of which 60% was from crops and 40% from livestock (Table 2). Besides agricultural production proper, there is an industrial sector that caters to agriculture. Production of fertilizers, biocides, computerized irrigation and dairy management systems, and various types of agricultural equipment not only supplies the local needs but also provides many items for export.

Distinctive features of the Israeli rural scene are the collective settlements (*kibbutzim*) and the smallholder cooperatives (*moshavovdim*) that together account for almost 80% of agricultural production in Israel. They also maintain a substantial industrial and service sector.

Table 2. Distribution of agricultural production in 1990 (% of total value).

Crops	
Field crops	11
Vegetables, potatoes, melons	16
Fruit	23
Flowers, ornamentals	10
Subtotal	60
Livestock	
Poultry	18
Dairy and beef	16
Sheep and goats	3
Fish	2
Others	1
Subtotal	40

Dryland Farming

Most dryland farming occurs in the 200–500 mm rainfall zone. Wheat (*Triticum aestivum*), the main crop, is grown for both grain and silage. Local wheat grain production supplies less than half the country's requirements; the remainder is imported. Secondary crops include sunflower (*Helianthus* spp.), safflower (*Carthamus tinctorius*), watermelon (*Citrullus vulgaris*), chickpea (*Cicer arietinum*), vetch (*Vicia* spp.) for hay, and small amounts of barley (*Hordeum vulgare*) and sorghum (*Sorghum* spp.). Production of individual field crops varies primarily in response to fluctuations in market demand.

Agricultural research in Israel has been conducted since 1909, when a wild progenitor of modern wheat (*Triticum turgidum* L. var. *dicoccoides* [Koern, in Schweinf.] Bowden) was discovered growing in the hills of Galilee (Aaronsohn, 1909). The scope and scale of agricultural research has increased dramatically since the establishment of the State of Israel in 1948. Much of the work on dryland agriculture has been summarized by Arnon (1992).

In the drier parts of the region, wheat is cultivated in either a continuous monoculture or a wheat-fallow rotation. Cultivation practices are intensive, with routine plowing and use of fertilizers, herbicides, and some fungicides. Straw usually is baled and used largely for bedding for dairy herds. Capital input per unit area is high and land units commonly are from 300 to 1000 ha.

Israeli farmers use improved cultivars that were developed by breeders in the research institutions and in private seed companies and tested in variety trials across the wheat zone. The cultivars are largely derived from semidwarf wheat germplasm common to many other dryland regions of the world except that they mature early and are not very sensitive to day length. The wheat breeding programs in the Agricultural Research Organization emphasize development of wheat varieties specifically adapted to low rainfall and high temperature (Blum, 1988). With the recent privatization of the wheat trade, high grain quality has become an important breeding goal.

Nitrogen fertilizer recommendations are based on many field trials and are supported by a widely used bioassay technique (Amir and Ephrat, 1971). This assay is being expanded to estimate phosphorus requirements and degree of nematode infestation.

Traditional wheat cultivation in the 200–250 mm rainfall zone yields about 700 kg/ha. Continuous wheat in the same region, using fertilizers, herbicides, improved cultivars, and timely mechanical cultivation and seeding, averages about 1500 kg/ha. Following a dry fallow period (wheat-fallow rotation), yields range between 2000 and 2500 kg/ha. Such yields can be obtained under continuous cropping only with chemical control of soil pathogens or possibly with mulch conservation tillage (Amir et al., 1991). With supplementary irrigation and in the higher rainfall areas, wheat yields are normally between 4000 and 6000 kg/ha.

Continuous wheat cultivation aggravates weed, pest, and disease problems. Root nematodes have become particularly prominent in recent years. Research has shown that these problems can be overcome with appropriate management and phytosanitation, but wide application of these measures often is constrained by economic, logistical, and sometimes environmental considerations.

Rainfall distribution varies widely from year to year, and total rainfall fluctuates greatly (coefficient of variation about 32%). Drought years are common, especially in the lower rainfall zone. In such years farmers can receive drought compensation from the government. However, even during "normal" years, wheat prices are negotiated between farmer organizations and the government. Recently, private trading has replaced government price setting. In the

past, supports encouraged continuous wheat cropping, but it is not yet clear how the new marketing arrangements will influence agronomic practices.

In much of the wheat zone, especially where annual rainfall exceeds 400 mm, other crops are available for rotations, particularly legumes for hay. Vetch and pea (*Pisum* spp.) are grown on a small scale and sulla (*Hedysarum coronarium*) has also been shown to be potentially useful as a hay crop. The area planted for hay production is limited by dairy herd demand, since roughages constitute only 25 to 30% of the ration, the remainder being concentrates and recycled agricultural wastes such as orange peel and whole cotton seed.

Dryland fruit crops include mainly olives (*Olea europaea*) and wine grapes, but figs (*Ficus* spp.) and pomegranates (*Punica granatum*) are also grown on a small scale. The wine industry has started producing quality wines in recent years, some for export.

Soil and Water Conservation

Conservation of flash flood water in farm dams, sometimes combined with recycling of sewage water, has added significantly to the water available for irrigation. Soil and water conservation methods in the field, common in the past, are being maintained on a reduced scale today, even though current cultivation practices expose the soil to erosion hazards, particularly at the beginning of the rainy season. Peak rainfall intensity occurs early in the season, when much of the soil is bare, and is about double the late-season intensity (Morin and Sharon, 1993). A comprehensive rainfall database combined with weather radar is now being used to monitor rainfall patterns and construct maps of maximum intensities for different durations and probabilities over continuous areas (Rosenfeld et al., 1993). This information, together with soil parameters, is used to design more efficient measures to prevent runoff. One technique that has been promoted successfully is shallow surface pitting on sloping land in the dryland farming areas (Morin and Benyamini, 1988). In the more arid areas, water harvesting is practiced to establish woodlots, largely for landscape enhancement and recreation.

Rangeland

Rangeland in Israel occupies almost twice the area of cultivated land (Table 1), and varies from shrubby steppe to mixed grassland to typical Mediterranean woodlands (Seligman et al., 1959). Rangeland is used primarily for beef cattle and sheep, and to a lesser extent goats. About one-quarter of the area is fenced for beef cattle operations, mainly in the more humid zone. The rest is open-grazed, largely by transhumant flocks of small ruminants. Range management research is conducted in the North on both Mediterranean grasslands and woodlands. In the semiarid part of the country, research has been conducted on pasture and on livestock-crop integration. This research has been complemented by research on sheep and beef management.

Nature reserves and national parks administered by the Nature Reserve Authority occupy large areas throughout the country. An active and strong Nature Conservation Society has considerable impact on land use and environmental protection. About 100,000 ha of hill country has been afforested with various pines (*Pinus* spp.) and other species, mainly for recreation and landscape enhancement. Additionally, eucalyptus (*Eucalyptus* spp.) woodlots may become important as an alternative crop on marginal dryland habitats in the more humid part of the country.

Problems and Constraints

Problems that face Israeli agriculture in general and dryland agriculture in particular are mainly related to economic sustainability. Low international prices and local market saturation have made many traditional dryland crops economically unattractive. Consequently, there has been an intensive search for appropriate innovative crops, like jojoba (*Simmondsia californica*) and canola (*Brassica napus*) and for appropriate varieties of "traditional" crops like sorghum. Constantly changing socioeconomic conditions have been matched by dynamic change in agricultural practices and in land use. Agrotourism is being actively developed in addition to the many recreation centers in rural settlements.

As in many parts of the world, Israeli agriculture is becoming increasingly linked to the economies and logistics of the urban, industrial, and recreational sectors. Although this has caused major dislocations, it also raises many challenges for innovative research and development. These include: management for higher output/input ratios in both dryland and irrigated crops; crop diversification; conservation and improvement of genetic resources; integration of crop and livestock production; alternative land use options, including unconventional uses like agroforestry, recreation, ecological refuges and landscape enhancement; and other requirements (like management of highway vergers) that are demanded by an increasingly complex urbanized society. Agroecological issues are gaining prominence as environmental and food quality become increasing concerns.

These challenges are common to most countries in the region and many other regions, including the U.S. Pacific Northwest. They not only determine the objectives of current research but also create opportunities for international and regional collaboration. These challenges to agriculture engage many disciplines ranging from soil, crop and animal sciences to ecology, economics, sociology, simulation modeling, and systems analysis.

Agricultural Institutions

In Israel, agricultural research is conducted by several institutions including: the Agricultural Research Organization (ARO) of the Ministry of Agriculture, the agricultural faculty of Hebrew University, the Kimron Veterinary Institute, the Department of Agriculture and Applied Biology of the Ben-Gurton University of the Negev, and various departments in other universities. There are seven institutes in the ARO: Field and Garden Crops, Animal Science, Fruit Crops, Soil and Water, Plant Protection, Food Technology, and Agricultural Engineering. The main campus is the Volcani Center, Bet Dagan, near Tel Aviv on the central coastal plain. There are also two major regional experiment stations, Newe Ya'ar in the North and Gilat in the South. Range research is done at the Karei Deshe Experimental Range Station near the Sea of Galilee, and arid pasture research at the Midga Experimental Farm, a substation of Gilat. Collaborative research on agroecosystems, much of it international, has made it possible to integrate local experimental

work into regional development analysis programs and crop models (e.g., van Keulen and Seligman, 1987; Ungar, 1990; Amir and Sinclair, 1991; Alberda et al., 1992).

The extension service of the Ministry of Agriculture invests considerable effort in initiating innovation and development. The agriculture sector itself is also actively involved in regional R&D projects, especially in intensive, irrigated agriculture, including greenhouse agriculture, and in extensive rangeland-animal husbandry.

Regional Collaboration

International collaboration is a major function of the agricultural R&D establishment in Israel. A special division of the Ministry of Agriculture (the Center for International Agricultural Development Cooperation) coordinates international collaborations and conducts a wide range of training courses in many aspects of agricultural practice and administration. All research organizations in Israel maintain strong international connections on both the official and the personal level. Much of the research is collaborative and is supported by national, binational, and international foundations.

Meeting the challenges in agriculture in the Middle East requires a wider collaborative framework with those whom we have so much in common and with whom we have had so little contact in the past. Together with the Palestinians, the Jordanians, and the other peoples of the Middle East, particularly the Egyptians, who have led the way for more than a decade, we can work together to improve the efficiency, diversity, and sustainability of farming in the region. A basis for technological cooperation in agricultural research exists in many areas. A short list of current R&D topics includes:

- sustainable agriculture in both intensive and extensive contexts
- crop diversification and breeding for specialty varieties
- multiple-use management of agricultural land and rangeland
- integrated nutrient management for better production efficiency and environmental protection
- irrigation technology and practice
- forestry and agroforestry in both arid and more humid Mediterranean situations
- agroecology of problem habitats
- integrated land use planning and development.

We in Israel look forward to an interesting future and hope we are not alone in seeing this future as one of free professional and technological exchange among all countries in the region.

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Swissair Now Serving Organic Food on Its Flights

Swissair is now serving organically-grown products in all classes of its in-flight food service on its flights departing from Switzerland. "The trend towards healthier foods is increasing all over the globe," according to the airline. "Swissair sees this as a chance to contribute to the health and well-being of its passengers."

In a recent survey of Swissair's frequent flyers, respondents felt that "organically-grown products should be used as much as possible." Within three years, the airline's "Naturalgourmet" organic food service is expected to be expanded to cover Swissair's entire route network, according to the airline, which is working with BioSuisse, the association of Swiss organic farmers, and the Swiss Consumer Protection Association on the project.

Dryland farming research in Egypt: Strategies for developing a more sustainable agriculture

Adel El-Beltagy, Youssef Hamdi, Mohsen El-Gindy, Awad Hussein, and Ayman Abou-Hadid

Abstract. *Developing and implementing water management strategies is imperative for achieving food self reliance in Egypt. Key elements of the strategy for increasing total value added from agriculture must be directed at enhancing efficiency of water use for crop production. This should be complemented by measures to ensure the efficient use and improvement of developed and undeveloped land resources. We examine the need to shift from supply management policies to demand management policies to optimize water use by farmers. Key features for sustainable development of agricultural water management include: greater investment; infusion of modern, appropriate technologies; building an adequate physical and institutional infrastructure; development of human resources and expertise; intensified cooperation and linkages; and technology development. Communities should be involved in reversing the trend from supply-driven to demand-oriented policies. This should be compatible with consideration of social dimensions.*

Key words: irrigation, wheat, pesticides, water resources, agricultural research

National Needs Assessment: Drivers For Changes

A limited arable land base and an ever-growing population with an annual birth rate of 2.7% are the main features affecting the food production/consumption gap in Egypt. Egypt's population will grow to about 70 million by the year 2000 and to 110 million by 2025. In the Nile Valley the population density is about 1300/km^2. Even if the agricultural land base were to double from 3.1 to 6 million ha, production of food would satisfy only 50% of the requirements of a population of 59 million.

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To bridge the food gap and to fulfill the goal of self reliance there is an urgent need to expand the land base and optimize agricultural outputs. Agricultural land has increased by about 0.80 million ha. However, because of urbanization, the new gain has been less than what it might have been. The per capita share of land declined from 0.05 ha in 1987 to about 0.04 ha in 1990. The current land reclamation program aims to develop an additional 1.2 million ha.

The critical constraint on agricultural development in Egypt is not land alone, but rather water resources to reclaim the vast land resources available. Egypt presently has about 1000 m^3 of water per person, approximately the reasonable threshold for development. This amount is projected to decline to 350 m^3 per person by 2025. Competition for water resources among all end-uses clearly will intensify. This underscores the urgent need for better management and efficient use of the finite resources available today if the development of Egypt's agriculture is to proceed.

Water Resource Quality and Constraints

Fresh water is a finite resource that is essential for agriculture, industry, and human existence. Without adequate quantities of fresh water, sustainable development is not possible. Three sources of water are available for agriculture in Egypt, excluding rainfed systems, which represent about 5% of agricultural lands.

The Nile system is the major source of water in Egypt and Sudan. The second source is the Nile basin, which is important in recharging ground water. The main aquifers in Egypt are the Nubian sandstone and alluvial aquifers (river-deposited) in the Nile Valley and Delta. Other shallow aquifers are of marginal quality because of salinity. Agricultural drainage water and sewage waste water represent the third category of water resources available (Tables 1 and 2). The construction of the old Aswan Dam, Aswan High Dam and major Nile barrages has led to greater control of the flow. As a consequence, the river's ability to flush its bed of sediment and associated pollutants

Table 1. Egypt's present and future water resources (billion m^3/yr).

Source	1990	2000
River Nile	55.5	57.5[1]
Groundwater	2.6	4.9
Agricultural drainage	4.7	7.0
Treated municipal sewage	0.2	1.1
Saving flow management	0.0	1.0
Deep groundwater	0.5	2.5
Total	63.5	74.0

[1] With completion of the first stage of the Jonglei Canal, which will increase Egypt's share from the Nile by 2.5 billion m^3/yr.

Table 2. Egypt's present and future water demands (billion m^3/yr).

Use	1990	2000[1]
Irrigation	49.7	59.9[2]
Municipal uses	3.1	3.1
Industrial	4.6	6.1
Navigation and regulation	1.8	0.3
Total	59.2	69.4

[1] Includes the irrigation requirements for an additional 0.6 million ha to be reclaimed by the year 2000.
[2] Additional requirements for the year 2000 will be secured through reducing losses from the present value of 50% to 20%.

at periods of high flow has decreased significantly. There are technical questions about the sustainability of the system because of salinity, excess nutrients, heavy metals, water logging, and pesticide residues (Table 3).

The water quality of the Nile above the reservoir and from Aswan to Cairo is fairly good. The Delta is characterized by stagnant water, low flow, low dilution and assimilation of wastes, production of macrophytes and heavy growth of algae, and high level of nutrients and organic matter. Water quality monitoring in Egypt is conducted by the Nile Research Institute (NRI). Water Research Center (WRC), Environmental and Occupational Health Center, National Research Center, Agriculture Research Center (ARC), and the Central Agriculture Pesticides Laboratory (CAL).

Chemical pollution

Pollution may occur from different sources, including disposal of industrial waste on agricultural land, atmospheric fallout, use of sewage sludge or effluent, pesticide residues, and intensive mineral fertilization. By far, the last two cause the most severe damage to the environment.

Within the River Nile Protection and Development Project, a joint study was carried out by NRI and CAL to monitor and analyze fifteen organochlorine pesticide residues in sediment and fish samples. Organochlorine pesticides were used extensively in Egypt after 1950 but have been prohibited since 1980. Samples from Lake Nasser showed a higher level of DDT residue than samples from other sites. This is attributed to the current use of DDT in Sudan. Not all the water samples contained organochlorine pesticide residues in amounts that exceeded the permissible limit established by the World Health Organization (WHO) for drinking water.

Fertilizer use has soared since the 1960s to compensate for the nutrients formerly supplied by the alluvial deposits now retained at the Aswan High Dam, and as a result of the government subsidy policy to increase both cropping intensity and the area under cultivation. According to Ministry of Agriculture and Land Reclamation statistics, fertilizer use during 1987–1988 was 990,000 tons of nutrient equivalents, or about 2.3 million tons of market product. This represents an average rate of 452 kg/ha (190 kg/ha if expressed in nutrient equivalent). This is a very high value compared with application rates worldwide but quite understandable in view of the high cropping intensity.

Legislative framework

A law to protect the River Nile and related waterways from pollution was enacted in 1982. However it has yet to be enforced, most likely because it did not include a realistic phasing in of discharge reductions to meet the standards. To enable enforcement, temporary permits incorporating realistic phasing of reductions and penalties for discharge of pollutants need to be considered.

Pesticide use in Egypt

The Ministry of Agriculture has strengthened laws and introduced new legislation to control and ensure the safe use of pesticides. Egypt has a stringent pesticide registration law that is principally based on biological efficacy studies, labeling, packaging, toxicology investigations, residue trials, and environmental safety. Through the regular meetings of The Codex Committee, the maximum residue limits are determined and recommended as consistent both with good agricultural practice and with the acceptable daily intake established by the WHO.

Use of modern pesticides has greatly improved pest control. However, because of environmental pollution concerns and increasing resistance of pests to pesticides, research is now concentrating more on integrated pest management (IPM), in which pesticides are used with other methods such as pheromones, beneficial insects, detection and sampling, economic thresholds, plant resistance, and cultural methods. Integrated pest management in cotton (*Gossypium* spp.), citrus, and tomato (*Lycopersicon esculentum*) is now well developed in Egypt, while other pest management programs are being verified for several other important crops.

Because of their long persistence and the rapid development of resistance by agricultural pests against their toxic action, chlorinated insecticides were completely replaced in the late 1960s by less persistent organophosphates and carbamates. Synthetic pyrethroids also are in use, as well as various insect growth regulators. These chemicals are safer and more compatible with the environment. The stringent pesticide laws regulating the use of these chemicals and the continuous efforts to implement IPM strategies in several crops have contributed to the annual decrease in pesticide use in Egypt (Fig. 1). Pesticide use in 1988 was 15,830 tons, gradually decreasing to only 6,086 tons in 1992. This shows clearly that the Ministry of Agriculture's

Table 3. River Nile flow downstream of the Aswan High Dam (AHD) and the drainage water quantity and salinity flowing to the sea.

Year	River Nile Flow Below AHD (billion m^3)	Drainage Water	
		Quantity (billion m^3)	Salinity (S/m)
1984–85	56.4	14.3	0.37
1985–86	55.5	14.1	0.37
1986–87	55.2	13.6	0.41
1987–88	52.9	12.3	0.43
1988–89	53.2	12.0	0.43

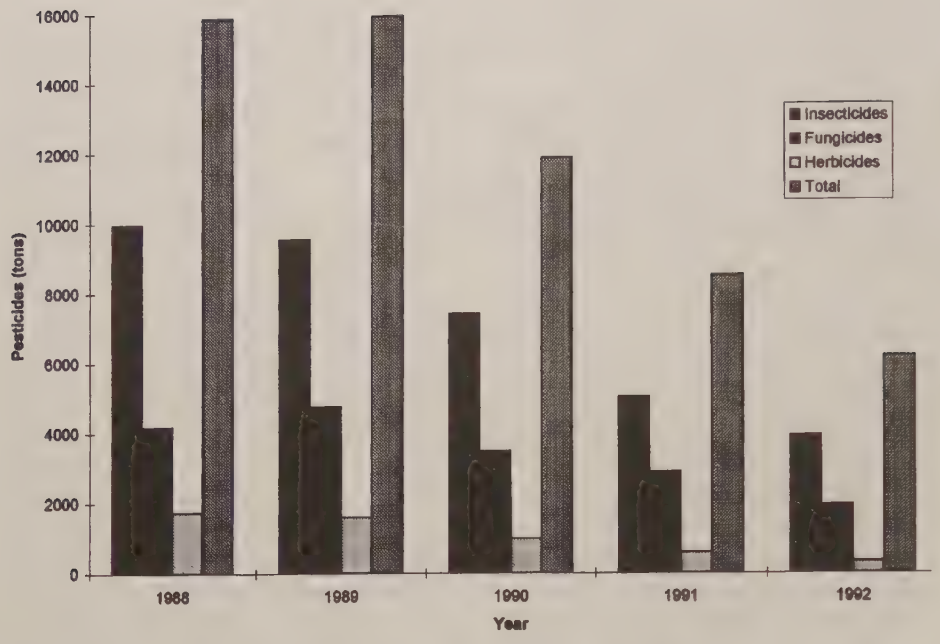

Figure 1. Amount of pesticides used in tons during the period 1988 to 1992.

pesticide regulation policy and IPM education, research and implementation have changed the outlook and practices regarding pesticide use.

Reuse of waste water

During the last decade, waste water reclamation, recycling, and reuse in agriculture have received much attention around the world, especially in the arid and semiarid regions. Waste water reuse in agriculture can provide several benefits: it can minimize waste water pollution, provide nutrients and fertilizers to the soil for increasing productivity, provide a reliable supply of water at reasonable cost, and most importantly, meet the need for large quantities of water for landscaping, soil modification, animal husbandry, and crop irrigation. Waste water use in agriculture is easily justified on agronomic and economic grounds, but care must be taken to minimize adverse health and environmental impacts.

About 3.1 billion m^3 (BCM) of the Egyptian share of Nile water is allocated for city uses. A large portion of this water enters the municipal waste water network. Cairo produces 0.9 BCM of waste water; by the year 2000, it is predicted to increase to 1.7 BCM and by 2010 to 1.93 BCM. By 2010, Alexandria will produce 2.2 BCM of waste water compared with a predicted 4.9 BCM for the country. Disposing of such a vast amount of water creates a serious environmental problem. Sewage treatment stations are being constructed in several locations near the major cities to purify the water before it is pumped to the waste sites (desert or large water bodies). Sludge usually is dried and prepared for use as a soil amendment. Pilot research units have been established near Cairo, Alexandria, and Ismaelia for controlling pollution and reusing waste water.

Aquaculture

Nile fisheries are the most important source of affordable protein for the Egyptian people. About one-third of the nonplant protein consumed is from fish. During the ten years 1982–1992, total fish production from all sources increased from 222,000 to 347,000 tons. Fish production in Egypt historically has come from various capture fishery sources, both marine and freshwater. Water pollution and overfishing are affecting the productivity of these natural resources.

Fish consumption in Egypt is about 7 kg per capita per year, which is below the world average. Fish production from aquaculture has increased faster than the total fish supply. In 1977, only 8.3% of the total supply was from aquaculture; in 1988 it was 12.7%. Approximately 30,000 tons of fish are produced annually through aquaculture. Egyptian aquaculture currently uses more than 42,000 ha, of which about 96% is in the private sector. This contrasts with the 71% private ownership out of a total of 12,600 ha in 1989.

The major type of aquaculture in Egypt is fish farming in earthen ponds using different levels of intensification. Most land used in pond culture is saline or alkaline with poor drainage characteristics and little potential for agricultural development. The use of fresh water from the River Nile and other irrigation canals for pond culture is prohibited. Only drainage water is available for such aquaculture. About 29,000 m^3/ha of water is required per year for filling and compensating for seepage and evaporation.

Cage culture is another form of aquaculture in Egypt. Cages are licensed in the River Nile and its branches. The number of cages has increased from 8 in 1985 to about 2000 in 1992. Tilapias (*Tilapia* spp.) are the principal fish cultured in cages. Cage culture in marine waters is currently being attempted.

Integrated agriculture/aquaculture also represents a developing area of Egyptian aquaculture in both rice/fish and animal/fish farms. Rice/fish culture was initiated in 1983 with 210 ha in production. Currently, rice/fish culture occupies about 168,000 ha. About 20,000 tons of fish are produced annually, with common carp (*Cyprinus* spp.) the major species. Integrated culture of ducks and fish is still at a preliminary stage.

Production of fish fry and fingerlings is needed for different aquaculture activities. Four hatcheries have been in operation since 1980 to support fish culture. Additional hatcheries are under construction in Upper Egypt, Alexandria, and Sinai. The use of water directly from the supply canals is allowed in fish hatcheries. Water quality is an essential factor in successful fish culture. Depending on the type of effluent used, water sources vary significantly in their content of sewage, heavy metals, suspended solids and pesticides, and require careful monitoring and management.

The National Aquaculture Center at Abbassa was established to support aquaculture activities. This was expanded to become the Central Laboratory for Aquaculture (CLA) to provide leadership in research

training and extension for applied aquaculture. Most professional staff members of CLA were trained overseas, mainly in the U.S. through funding provided by the U.S. Agency for International Development. About 70 research staff members currently are employed by CLA, which has joined with the Agricultural Research Center. The facility is well equipped with laboratories for research covering all aspects of the aquaculture industry.

On-farm Water Management

Irrigation systems improvement

Most Egyptian agricultural production depends on surface irrigation systems. Water is delivered to irrigated lands through several extensive canal systems consisting of principal canals that feed water from the Nile to several main canals, which branch to form smaller canals or *mesquas*. A mesqua serves about 40 to 200 ha and supplies water to individual farmers.

The mesqua system was developed to save water and improve water distribution efficiency. The water level in the mesquas is always 50 cm below ground level and farmers originally pumped the water with *sakias*, an animal-driven water mill (some still do today). Most of the sakias have been replaced by movable diesel-driven centrifugal pumps. Water is conveyed from the sakias or pumps to individual fields by small channels known as *marwes*, which typically serve 4 to 20 ha. The disadvantage of this system is farmers' lack of control in the timing of irrigation delivery.

Modifications were necessary to improve the water conveyance system, including the control structures, conveyance ditches, lifting devices, and pipelines. The improvement covers both operation and maintenance aspects. Several attempts to improve this system have been reported, including the canal linings, mesqua takeoff structures, drop structures, check structures, division boxes, outlets, and turnouts. These modifications were reported to improve the surface irrigation efficiency by about 25%. Furthermore, the introduction of laser leveling for the soil is essential to improve the uniformity of water application in the field and to minimize the waste of water on the farm.

On-farm irrigation management starting from the mesquas and up to the individual fields is the responsibility of the Ministry of Agriculture and Land Reclamation. Research, extension and training to improve irrigation systems and optimize farm water management are carried out by the Soil and Water Institute and the Agricultural Engineering Institute of ARC in collaboration with other institutes.

Improving old land irrigation system

The Egyptian share of Nile water is about 55.5 BCM per year, of which about 38 BCM is allocated for agriculture. The total area under irrigation in Egypt is about 3.1 million ha, of which 0.55 million ha has advanced irrigation systems such as drip and sprinkler, with surface irrigation on the remaining 2.6 million ha (Table 4).

The efficiency of surface irrigation can be as low as 50%, while advanced technology can improve the efficiency to 70% for sprinkler and 90% for drip irrigation systems. The major constraint to expanding agricultural lands through land reclamation is the availability of fresh water. The Land Master Plan for Egypt has identified 1.4 million ha of priority areas that can be reclaimed if water is available. Clearly, improving irrigation efficiency in the old lands is an effective way to secure water resources for the land reclamation program. If the irrigation efficiency of the old land is improved from 50% to 80% by improving canal systems and farm water application, this could save over 7000 m^3 per ha annually, for a total of about 18 BCM of water. This water saving could support a land reclamation program for an additional 1.3 million ha (14,000 m^3/ha annually).

Protected agriculture

Protected cultivation is a major method of agricultural intensification. In recent years the production of different crops under plastic has increased 3- to 8-fold in comparison with open field cultivation. Plasticulture is noted for its effectiveness for crop protection and high water use efficiency. For example, the water use efficiency of tomato under plastic houses is 15 kg of fruit per m^3 of water, compared with 1.6 kg/m^3 in open fields.

Protected cultivation is a tool for proper crop management that maintains cleaner and less polluted soil and atmosphere. Biological pest and disease control systems can be applied effectively in greenhouses, reducing the use of chemical pesticides. In addition, organic farming is more profitable when confined under plastic or glass compared with open fields.

Farmers have acquired technical knowledge of these techniques because of efforts by the agricultural research and extension system to produce technological packages for protected cultivation and low plastic tunnels for different agroclimatic zones. The area under plastic increased 7.5 fold in the last 7 years, from 2000 greenhouses in 1987 to 15,000 in 1992.

Low plastic tunnels are even less expensive than greenhouses and are quite suitable for some crops, such as tomato, cantaloupe (*Cucumis melo cantalupensis*) and strawberry (*Fragaria* spp.). The area under low plastic tunnels in Egypt increased from almost zero in 1985 to about 10,500 ha in 1992.

The use of hydroponic systems under plastic to optimize water and fertilizer use efficiency were evaluated at several research and development sites. A technology

Table 4. Area irrigated by modern methods and systems in Egypt (1993).

Irrigation System	1000 ha	%
Sprinkler irrigation (total 1+2)	357	65.4
1. Portable hand moved system	273	50.0
2. Other systems (permanent and solid set; side roll; traveling gun; center pivot)	84	15.4
Micro-irrigation (total 1+2)	147	26.9
1. Drip	145	26.5
2. Mini-sprinklers and bubblers	2	0.4
Surface irrigation using laser technology	42	7.7
Total	546	100

package was developed from these cumulative efforts for modified nutrient film and sandponics techniques for growers in the Sinai and the Red Sea, where water resources are very limited. In the nutrient film technique (NFT), a soil bed is prepared on a slope and a polyethylene gully laid over it. Nutrient solution is circulated from the catchment tank at the lowest end to the highest point of the slope. It then moves by gravity through the gully back to the tank. Evapotranspiration in this system occurs only through the plant, and water use efficiency approaches 100%, compared with 85% for well-designed drip irrigated plasticulture and 40–60% for open field cultivation.

Recirculated sand culture is a substrate-based hydroponic system that can efficiently use natural materials in modern systems for producing cantaloupe, cucumber (*Cucumis sativus*), and pepper (*Piper nigrum*). Like the NFT system, the sand culture is prepared by excavating rows in problem soils and lining them with polyethylene sheets before filling them with "clean" sand. Nutrient application is accomplished using drip systems. The excess water is collected in a tank and is modified daily by adding water and concentrated nutrients to the desired level for re-use as irrigation water in the closed system. The adoption of such techniques in the Red Sea area and Sinai can provide fresh vegetables to meet the needs of local tourism, industry, and residents, and to reduce the necessity for transporting fish from the Nile Valley to these areas.

The application of soil conditioners as either organic matter or synthetic polymers can substantially improve the water- holding capacity of the sandy soil. Soil conditioners can hold up to 200 times their weight in plant-available water in sandy soils. Several types of soil conditioners show promise for increasing water availability, especially in woody tree nurseries and protected cultivation of vegetables. The commercial manufacture of these materials is being considered.

Human infrastructure was an objective of several research and development programs in protected cultivation. Training programs for were made available for growers and university graduates. More than 1600 people were trained in five years. They were considered a core for the development of plastic-house farming in Egypt and some other Arab countries.

Improving crop efficiency traits

The need to conserve water resources leads logically to management practices that promote greater water use efficiency. One available option is to encourage farmers to select crops that inherently produce higher yield per unit of water. This is a topic that has been broadly developed, and wide cropping options are available to farmers. Management practices with such nontraditional crops must be transmitted to the farmer through extension education.

An additional strategy is to select early maturing cultivars of traditional crops. This could save one or two irrigations and therefore reduce water requirements. Earlier-maturing varieties may allow for new cropping strategies on limited arable land, including multiple cropping. New marketing opportunities would then be available to the grower. Diversification of farm products may make the farmer less vulnerable to a decline in the price of a given commodity.

An added benefit of early maturing varieties is that they shorten the period in which the crop is vulnerable to pathogens and pests, thus reducing the need for pesticides. Over the longer term better cropping rotations may be developed, which also should help control soilborne pathogens. For these reasons early maturity should be an important trait in crop improvement research.

Using Modern Technology in Crop Production

The ARC is using three high-technology systems to enhance agricultural development. The first is genetic engineering to implement advances in biotechnology to support agriculture. The second is expert systems as an agromanagement decision-making tool. The third is Landsat technology for proper management of natural resources (El-Beltagy, 1992).

Tolerance of adverse environmental conditions

A major thrust for genetic engineering is improving salt and drought tolerance, which could substantially increase crop production not only in Egypt but also in other developing countries. The production of salt-tolerant strains of plants for salinized areas could be achieved by adopting unconventional methods of plant breeding. Partnerships involving traditional plant breeding methods and contemporary molecular genetic engineering technologies have been established through the Agricultural Genetic Engineering Research Institute and ARC-University breeders to alter a crop's genetic make-up for improved adaptation to water-restricted environments. This includes various water-related tolerances as heritable features, such as tolerance of drought, temperature extremes, desiccation, salinity, and waterlogging. The goal is to manipulate components of the plant that condition higher productivity per unit area or promote higher yield per unit of available water. Adapting crops to marginal environments represents another tool to optimize management and utilization of available water resources. Whether this can be achieved without major sacrifices in yield potential is a matter of conjecture.

Computer expert systems

Computer expert systems can help with management decisions to increase crop yields and improve the quality of agricultural products. They also can aid in planning for optimizing the use of water and land resources for crop production. These agromanagement decisions can involve irrigation, nutrition, fertilization, and pest control. By using an expert system, workers can improve their management capability to an expert's level, thereby improving their effectiveness in achieving a more sustainable agriculture.

Landsat technology and agriculture

Landsat imagery is becoming extensively used in agriculture, land-use planning, and environmental monitoring. This will continue to increase as the technology advances and users gain experience with this new tool. The Landsat system not only gathers the data, but also digitizes the data for computer analyses. This provides for precise monitoring in several areas:

- Settlement and urban encroachment on fertile agricultural land
- Estimates of crop area for individual crops

- Early detection of plant diseases, water stress, and nutrient deficiency.

Geographic Information Systems are the fundamental technology for merging various independent sources of spatial data (maps) into forms that represent information. Within the ARC institutions and laboratories, research on genetic engineering and use of expert computer systems and Landsat technology could serve the goals and objectives of agricultural development not only for Egypt, but also regionally through joint research programs and training.

Experience with Wheat Production

Wheat cultivation in the Northwest Coast of Egypt

Studies of the potential for wheat production in the Northwest Coast of Egypt have shown positive results. Consequently, the Northwest Coast project was established to reclaim 30,000 ha along the Nasr Canal to produce 75,000 tons of wheat annually.

The study concluded that the following requirements must be met to ensure sustainable wheat production systems for this region:

1. Two supplementary irrigation applications are required during the critical stages of plant growth.
2. An accurate survey is needed of all areas that are suitable for mechanized wheat production.
3. Contour maps of selected locations are needed for locating dam sites for the most efficient water distribution systems.

Concerning (3), remote-sensing maps for the selected locations are needed to allocate water catchment or water harvest areas for each location to improve the incoming water yield. This should be started for the western areas, which have permanent water resources, and then expanded to the other areas.

Wheat production under salt-affected soils

Since 1980 there have been several experiments to improve wheat productivity using saline water (3200–3800 ppm), or in calcareous soil in Wady-Sedr in the south of Sinai. Some key findings from this research are:

- The best cultivar under saline conditions is 'Sakha-8,' which had been developed in Egypt to suit the North Delta region, with special reference to salinity tolerance.
- More frequent irrigation—about 10 times with saline water—is necessary to minimize the increase of soil salinity or to reduce the impact of salt on the root system during the critical growth stages.
- Each 0.1 S/m increase in water salinity above 0.6 S/m decreases wheat yield about 8%. The 0.6 S/m limit could be raised by spraying certain growth inhibitors into the water for one cycle or more and then imposing complete drought.

The Agricultural Research System

Agriculture is still considered the cornerstone of the Egyptian economy. The consequences of its development are reflected in the welfare of society. Of all production areas, agriculture is the most difficult to get to absorb development efforts, so that patience, drudgery, and hard work are needed to see its fruits. However, agricultural development will continue to be a fundamental factor in ensuring a sound economy.

Research is one of the most important tools for agricultural development. It is responsible for the biggest increase in agricultural production in developed countries.

The future vision of an integrated agricultural development strategy depends on several principles, among which are the following:

- Enhancing scientific research and technology to serve development
- Mobilizing the available human resources
- Developing and investing in Egyptian lands
- Improving the efficiency of agricultural resources and livestock.

There is no doubt that substantial achievements have been made in both plant and animal production. These achievements have come from applying research results. For instance, the following increases occurred in average crop yields in the period 1986–1991: wheat, 33.3%; maize, 5%; rice, 27.3%; faba beans, 15.3%; lentil, 45.3%; peanuts, 2.4%; sesame, 11.9%; sugar cane, 13.6%.

Undoubtedly, these positive results have not come from individual efforts or from concentrating on one discipline. Many scientific institutions have participated in various ways in the execution of several programs.

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Chemicals Possible Cause of Rise in Children's Cancer

The rate of cancer among American children has been rising almost one percent a year for decades, with many experts suspecting "the increase may be partly the result of growing exposure to new chemicals in the environment," according to *The New York Times* (September 29, 1997). "Although the causes are not known and are probably many, some experts say, toxins in the air, food, dust, soil and drinking water are prime suspects."

According to Dr. Philip Landrigan, senior adviser to the EPA's office of children's health, "the strong probability exists that environmental factors are playing a role." In their research, experts will probably examine "the estimated 75,000 new synthetic chemicals introduced in the last half century, the emissions from cars, the pesticides in foods and in neighborhoods—the whole collection of chemicals out there."

If there is a link between childhood cancer and chemicals, the results could be an expansion of federally supported research and eventually, tighter controls on pesticides, toxic wastes, and other chemicals, according to the article. "I'm talking about new research on air pollutants, water pollutants and pestcides, and their effects on children," said EPA Administrator Carol Browner.

Soil, water and crop management practices in the dryland farming regions of Turkey

M. Sefik Yesilsoy and Sabit Ersahin

Abstract. *Turkey is experiencing pressure to increase crop production per unit area to achieve self-reliance in food supply. The main production concern before 1970 was to increase crop yields to meet the national consumption of an ever-increasing population. During this time the country's capability to produce wheat was insufficient to meet the national demand. After the initiation of the National Wheat Research and Extension Project in 1969 the objectives of wheat production methods were changed to achieve not only higher but more economical yields per unit area. As a result the total area sown to wheat increased by only 9% between 1969 and 1990, whereas yields and total production increased 75 and 90%, respectively. This was due to developing or importing high-yielding varieties adapted to dry areas, increasing use of fertilizers and plant protection chemicals, and timely use of proper tillage made possible with modern equipment. Transferring research results to farmers and exchanging information with international scientists led Turkish scientists to establish the new goal of developing ecologically sound farming systems that could achieve higher, more economical yields per unit area. The key to this approach is to maintain or increase soil organic matter.*

Key words: wheat, dryland agriculture, water conservation

Introduction

Arid and semiarid regions make up almost 40% of the world's land area and are inhabited by some 700 million people, most of whom are farmers living in what we call Developing or Third World countries. Crop and livestock production often are limited here by insufficient rainfall and infertile and erodible soils. In these areas yields are extremely low compared with those of the humid and subhumid regions. Unfortunately, the population in many of these regions has increased rapidly during the past two or three decades, which has led to overgrazing by animals, increased cultivation for production, and increased cutting of shrubs and trees for firewood. The result has been an alarming loss of fragile croplands to desertification or a severe decrease in their productivity.

Only through the development of sustainable and environmentally sound agriculture systems for arid and semiarid environments will desertification be controlled and the ultimate disaster of malnutrition, famine, poverty and human misery be avoided. However, in many dryland areas, population growth prohibits a return to ecologically sustainable fallow or rotation systems (Parr et al., 1989).

Turkey has a population of about 60 million people living on 780,000 km^2 of land, with a birthrate of 2.6%. Approximately 40% of the total land area is classified as semiarid. Of this, nearly 60% is in the Central Plateau. Most of the country's interior is dryland. According to most economic indicators Turkey is considered a developing country.

Like most other Mediterranean countries, increasing population growth and limited land resources are creating pressures to produce more food per unit area of land. In Turkey, wheat production is a key indicator of the country's agricultural activity and agronomic progress in the dryland areas.

Production Goals

The main production concern before 1970 was to produce more yield per unit area to meet the consumption of a growing national population. Figure 1 shows that the increase in wheat production before 1970 was due mostly to the increase in the area sown. The yield and production fluctuations were primarily due to weather. Before 1970 wheat production did not meet the national demand, and some grain was imported.

After the National Wheat Research and Extension Project was initiated in 1969, the national goal was to develop and implement technologies to increase wheat production with a greater emphasis on economical yield per unit area. Because of this new thrust, the area sown to wheat between 1969 and 1990 increased only by 9%, whereas yield per unit area and total production increased by 75 and 90%, respectively (see Fig. 1). This was due to increased use of chemicals for plant protection and fertilizers for nutrient supply, and timely use of proper tillage made possible with modern equipment. All these factors comprised an agronomic package that was made available to the farmers.

Since most of the wheat is produced without irrigation, exceptionally dry years,

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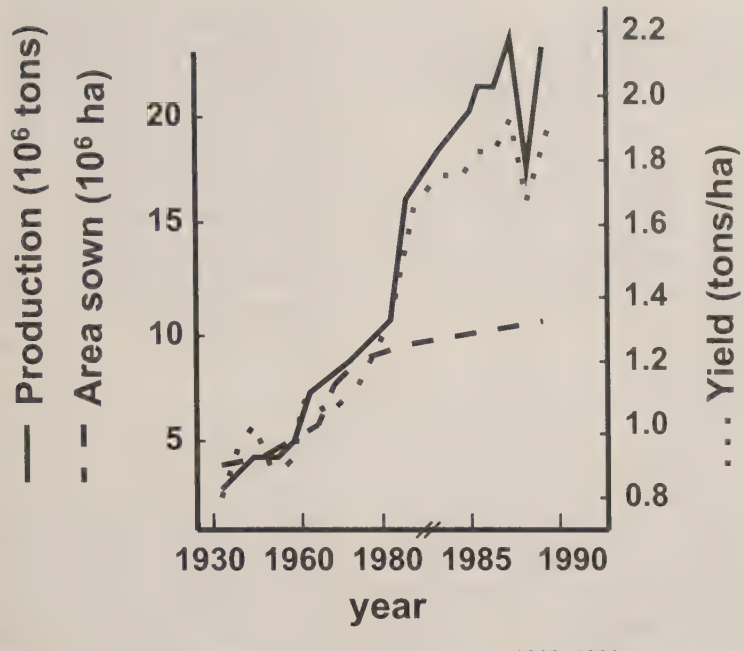

Fig. 1. Area sown, production, and yield of wheat in Turkey, 1930–1990.

such in 1989, can affect yields very dramatically. Guler (1988) developed a relationship between wheat yield and weather factors such as temperature and rainfall during the growing period. He found that the equation could predict the yield only when all factors other than weather are kept at an optimum.

Advances in Water Conservation

During the development of agronomic practices after 1970 considerable research was conducted on tillage methods to conserve water and prepare a proper seedbed during fallow. Because of low and erratic precipitation, a main objective of production practices in the dryland areas is to conserve moisture during fallow for the subsequent wheat crop. This is accomplished through timely use of proper tillage equipment. Field trials and laboratory research showed that evaporation from soils with high clay content was not effectively controlled by stubble cover during an extended dry period (Yesilsoy, 1990). However, creating a dry and porous tilled layer soon after a wet period slowed evaporation and increased fallow efficiencies (Fig. 2).

It was concluded from these studies that for clay soils characteristic of much of the Turkish drylands, clean tillage using the moldboard plow as the initial tillage implement and creating a porous soil mulch during the dry season was superior to stubble mulching for water conservation during fallow. It was also found that moisture was lost from clay soils during extended drying periods not only from near the surface, but unlike with sandy soils, also from greater depths (Yesilsoy, 1990). This was observed in the clay soils of dryland areas of Central Anatolia; thus it was postulated that soils shallower than 90 cm should not be fallowed but instead be cropped annually. Later, other research and farmer experience supported these findings and the boundaries of the fallow areas were redefined, which reduced the fallow area by about 3.4 million ha between 1969 and 1990. With more efficient moisture conservation, more water is available for evapotranspiration; combined with improved agronomic practices, this has made it possible to harvest more wheat per unit area (Fig. 3).

Soil Quality and Sustainable Crop Production: The Future

Extending research results to farmers and exchanging information with international scientists led Turkish scientists to establish a new goal for sustainable crop production in dryland areas, i.e., to develop ecologically sound farming systems that can achieve economical yields per unit area. The key to this approach is improving soil quality. Soil quality can be defined as "the capability of a soil to produce safe and nutritious crops in a sustained manner over the long-term, and to enhance human and animal health, without impairing the natural resource base or harming the environment" (Parr et al., 1992).

Soil quality can decline from various causes, not just wind and water erosion, but also from degradative processes such as nutrient losses from runoff and leaching, depletion of soil organic matter, crusting, compaction, and desertification. It also can occur through accumulation of toxic substances from excessive use of chemical

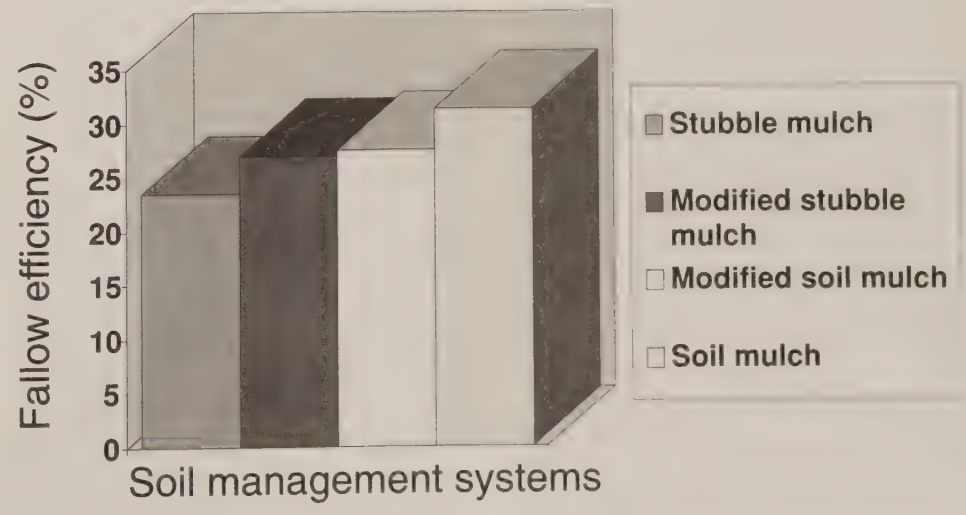

Fig. 2. Effect of soil management systems on average fallow efficiency, 1976–1980 (Durutan et al., 1986).

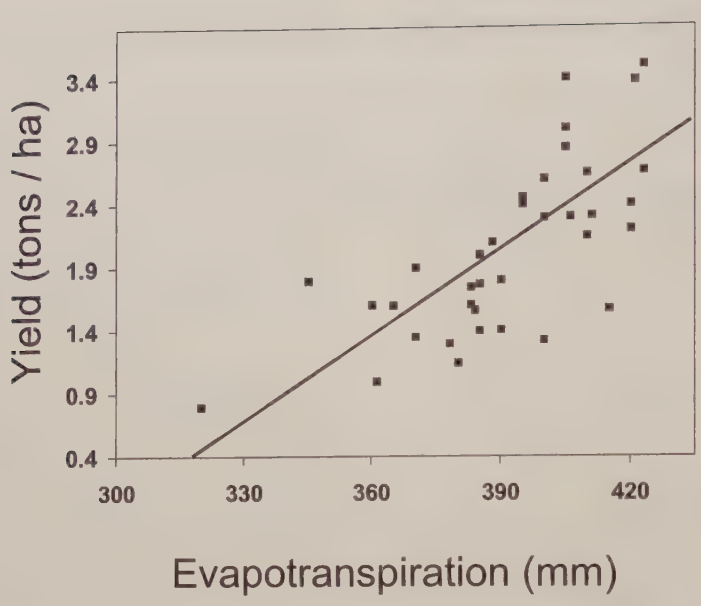

Fig. 3. Average wheat yields and evapotranspiration values for 1970–1972 fallow-crop tillage research trials conducted at Ankara (Lodumlu), Polatli, Altinova, and Gozlu State farms.

fertilizers and pesticides or improper waste disposal. The maintenance or restoration of soil quality is highly dependent on soil organic matter and the array of beneficial macro and microorganisms that it supports. Proper and regular addition of organic amendments such as animal manures and crop residues can effectively control many of these degradative processes. Crop residues returned regularly to the soil can enhance soil and water conservation and hence sustain soil productivity and increase crop yields. Unfortunately, crop residues often are completely removed for animal feed or burned.

As explained earlier, in Turkish dryland areas a soil mulch (clean tillage) during fallow conserved more moisture and achieved higher wheat yields than stubble mulching. In this system of soil management, crop residue, or what remains of it, is buried by plowing instead of being retained at the soil surface. However, farmers and scientists must realize that with this clean tillage system, organic matter maintenance is very important for sustaining crop production. Regular additions of organic materials through crop residue management can help improve soil fertility and the soil chemical and microbiological properties that are important for healthy plant growth. Also, increases in organic matter benefit soil physical properties, which can increase water infiltration, water-holding capacity, water content, aeration, permeability, soil aggregation, and rooting depth. Adding organic matter also will help to reduce soil crusting, runoff water and nutrients, and bulk density of the heavy clay soils. Unger et al. (1991) suggest practices that can aid crop residue management, including limited or selective residue removal, substituting high-value forages for crop residue as animal feed, alley cropping, using wasteland areas for animal production, balancing feed supplies and animal population, and using alternative fuel sources as substitutes for crop residues. Tillage research trials in Central Anatolia showed that the soil organic matter content was increased by 0.5% by proper and timely tillage where grazing was prohibited (Yesilsoy, unpublished data).

Switching from fallow to annual cropping has required a new look at "best management practices" for controlling soil erosion and maintaining soil productivity in this different cropping system. Research has now been initiated on this subject.

Climate and soil are the two factors most critical for determining the sustainability of an agricultural system. Parr et al. (1990) discussed how the variability of temperature and soil moisture regimes affects long-term agricultural sustainability. As the temperature increases and precipitation decreases, usually it becomes more difficult to achieve sustainability.

The fragility and importance of the soil and water resource base in dryland agriculture must receive greater recognition, at both the national and on-farm levels. Productivity cannot be sustained if the resources that support it are degraded.

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Profile of organic dairy farming in Ontario

Yetunde O. Sholubi, D. Peter Stonehouse, and E. Ann Clark

Abstract. *Eight dairy farms located in western Ontario were surveyed as part of an ongoing comparative economic study. The sampled farms had been using organic methods for an average of 5.5 years and, therefore, were beyond the "transition" stage. Diversified cropping systems were characteristic of these farms, with most crop products (grain and straw) being used directly by the farms' livestock enterprises. Crop rotations were complex, and generally involved sequences of forages and small grains into which cover crops such as oilseed radish and red clover were integrated. Weed control, year-round soil cover, and production of feed and bedding all contributed to the design of cropping systems. Both solid and liquid manures were composted before application. No feed additives or growth hormones were used, but homeopathic remedies, probiotics, and antibiotics were commonly used. The high cost of synthetic fertilizer and concern for the environment were the main reasons given by the farmers for adopting organic methods.*

Key words: organic farming, crop rotation, forage, hay, profitability, pasture, small grains

Introduction

Aggregate demand for food, particularly livestock commodities, has continued to expand as both the human population and standard of living have increased on a global scale. Increases in food production, particularly in the developed market economy countries, have been achieved by adopting capital- and resource-intensive approaches such as mechanization, enterprise specialization with monocultures or simplified crop rotations, and the use of agrochemical products, including biocides and inorganic fertilizers (Frey et al., 1984; Carey, 1991; Carnevale et al., 1991).

Until the development of modern agricultural chemicals in the 1940s, cultural and mechanical approaches were used both to control pests and to supply nutrients to crops (Barker, 1975; Carey, 1991). Because yields of major field crops and rates of production from key livestock enterprises have increased several-fold since 1940 (Surgeoner and Grieve, 1994), some have concluded that low yields and uncompetitive economic performance are inevitable for an agriculture that does not use modern-day agrochemicals (Council for Agricultural Science and Technology, 1980). Others report that the relative performance of "conventional" resource-intensive agriculture and "alternative" forms of agriculture, such as ecological, low-input, or organic farming, varies among farms, enterprises, years, and even fields. The U.S. Dept. of Agriculture (1980) reviewed 69 on-farm case studies in 23 states, and concluded that organic farming systems were not limited by scale and that the perception that organic farming is a return to the 1930s was not consistent with current practice. Organic farmers used modern machinery, recommended crop varieties, certified seed, and sound methods for managing manure, soil, and water. Such findings were supported by Parr et al. (1990), who asserted that yields and net returns of low-input farmers were at least comparable to, if not higher than, those of their conventional neighbors.

A study undertaken by the National Research Council (1989) found that yields with alternative systems across a wide range of U.S. operations could be higher or lower than conventional yields, depending on site and year. Yields achieved under organic and conventional farming systems were contrasted in another review involving 205 comparisons (Stanhill, 1990). Using multi-year data from 26 crops and two animal products, the ratio of organic to conventional yield was normally distributed with a mean of 0.91, a standard deviation of 0.24, and a mode between 0.8 and 0.9. Almost one-third of the ratios were greater than 1.0, predominantly because of the superior performance of organic milk production. Variation among fields and years was reportedly greater than variation between cropping systems. This suggests that yield is not determined entirely by agrochemical use. A further implication is that dairying may be well suited to organic methods.

Alternatives to the conventional agriculture paradigm have been sought because of problems that have emerged in recent decades. Soil degradation and erosion were the main concerns as recently as 1989, but the current focus is on nonpoint-source pollution, wetland protection, biodiversity, and agrochemical pollution (Zinn and Blodgett, 1994). Agriculture has been identified as a leading contributor to nonpoint-source pollution (Duda and Johnson, 1985; Papendick et al., 1986; Fleming, 1987), and has been implicated in the destruction of wildlife habitat and concomitant loss of biodiversity (Papendick et al., 1986; Paoletti and Pimentel, 1992). Concerns about long-term social and environmental costs of agrochemical use have been documented with increasing rigor (Molder et al., 1991; Pimentel et al., 1993).

It has been argued that adopting more ecologically sustainable agricultural practices would reduce agriculture's damage to the environment (Crew et al., 1991). Organic farming has been described by the U.S. Dept. of Agriculture (1980) as a production system which avoids or largely

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excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth and to control insects, weeds, and other pests.

The key feature of organic farming in particular, or ecologically sustainable agriculture in general, is not simply abstinence from agrochemical use, but rather the intentional integration of natural processes to achieve various goals, including a productive agriculture. For example, explicit encouragement of natural biocontrol processes avoids the risks of biocide use, including carryover of residues or biocide-resistant microbes into the human food chain. Crop rotations designed for year-round soil cover, using perennial forages, winter small grains, or cover crops, reduce soil erosion and degradation (Stevenson, 1982). A concomitant benefit occurs from building up soil organic matter (Reganold et al., 1987), which serves as a sink for carbon dioxide (Rayburn, 1993). Nitrogen may be cycled more effectively within the farm and pose less risk of groundwater contamination. Dependence on on-farm N synthesis by leguminous crops, coupled with composting of animal wastes before land application (Gray and Biddlestone, 1981), enhance both economic and environmental soundness. Taken jointly, these features of organic practice serve to reduce harmful off-farm effects of agriculture (Faeth et al., 1991).

This ongoing study is designed to document the production and management strategies used on organic dairy farms in Ontario. We chose dairying because of its importance to Ontario and Canada and because of foreseeable institutional changes occurring within the Canadian dairy industry. Ontario contributed about one-third of all Canadian dairy production in the 1980s and 1990s (OMAF, 1982-1992) and dairying is the most important source of farm income in Ontario. The dairy industry also is among the most protected in Canadian agriculture, although recent World Trade Organization decisions have encouraged alternative practices to meet future production, marketing, and trading scenarios.

Research procedures and objectives

Our primary objective was to inform not only researchers and advisory staff about the realities of commercial organic dairying but also to give a firmer foundation to conventional producers interested in alternative means of milk production. The following questions were addressed in this study:

- What is the range of farm sizes over which organic dairying is practiced; in particular, is the organic approach limited to small farms?
- How do the labor requirements of organic dairying compare with those of conventional dairying?
- How do organic producers resolve problems such as soil nutrient depletion and weeds without using synthetic fertilizers and biocides?
- Is profit maximization the primary motivation of organic farmers, as widely assumed by economists to explain producer decision-making behavior?

Four provincial farmers' associations whose members used organic methods were asked to identify dairy members who might participate in the research: the Biodynamic Society of Ontario, the Ecological Farmers Association of Ontario, the Christian Farmers Federation of Ontario, and the Organic Crop Improvement Association of Ontario. We identified a total of eighteen farmers as specializing in dairying, of whom eight completed and returned a mailed questionnaire. We conducted this study using 1988 to 1992 production data.

Results and Discussion

Farm size

The organic dairy farms had an average of 121 ha of tillable land. The predominant dairy breed was Holstein, although one farm used Jersey cows. The milking herd (excluding replacement heifers) ranged from 29 to 72 cows, with a mean of 48. Only one farm had an additional commercial livestock enterprise (beef). Replacement heifers for the dairy herd were raised on each of the eight farms. In the 5 years from 1988 to 1992, the average annual replacement rate of cows on these farms was 21%. The Jersey farm had the highest replacement rate (44%). Among the seven Holstein farms, average replacement rate was 18%. Average calving interval was 13 months. The organic farms produced an average of 282 thousand liters of milk in 1992, ranging from 190 to 419 thousand liters. Milk produced per cow ranged from 4,328 to 7,692 liters, with an average of 5,882 liters. The farms used an average of 2.0 person-equivalents of labor in 1992 (range: 1.5 to 2.6).

To compare organic dairy producers with conventional Ontario dairy producers, we used the published results of the Ontario Dairy Farm Accounting Project (ODFAP) for conventional dairies. On average, conventional dairy farms had 99 ha of tillable land (22% less than organic farms), supporting 45 cows (7% less than organic farms) (OMAF, 1993). Milk production per farm was 264 thousand liters (7% less than on the organic farms). Milk production per cow (5,865 liters) and the amount of labor used (2.1 person-equivalents) were similar to those on organic farms.

Economic characteristics

On a whole farm basis, the organic farms had 9% lower revenue although they shipped more milk than the conventional farms. This discrepancy could have arisen in at least two ways. First, organic farmers may have produced more manufacturing milk, which has a lower price than fluid milk. Also, the difference in revenue was about equal to the income generated from the sale of other (nondairy) livestock on ODFAP farms.

Organic farms' expenses were 23% lower than conventional (ODFAP) farms' because of their reduced levels of purchased inputs such as seeds, livestock feeds, and livestock replacements, and especially their nonpurchase of synthetic fertilizers, biocides, hormones, and feed additives. Overhead costs such as depreciation and insurance also were lower on organic farms.

Net farm income for the organic farms was 52% higher than for the average ODFAP farm. Net farm income is the residual return to unpaid operator labor, family labor, management, and risk-taking. Net

farm income per cow and per hectare were 43% and 29% higher, respectively, on the organic farms. Organic farmers were more specialized in dairying; that is, they had fewer enterprise lines, although they were diversified in the crops grown to feed the dairy herd. Organic dairies were more self-sufficient in plant nutrients, animal nutrients, and animal replacements, and were more energy efficient; all these helped to reduce costs of production.

Organic farmers did not receive any price premium for their product until late 1994. Organic milk was pooled with other milk produced in Ontario and marketed by the sole licensed marketing agency, the Dairy Farmers of Ontario. However, after the study, a group of organic producers was issued a license to label and market their milk through a separate organic stream.

Crops and cropping practices

The organic dairy farmers grew a variety of crops, emphasizing forages and spring and winter small grains, but including soybean and corn to a minor extent (Table 1). Crop rotation was a key management tool in weed and pest control and in maintaining good soil fertility and structure. Rotations were based on the farm livestock feed needs and on soil building, plant nutrient conservation, and weed and pest control. They were also based on the demand for and availability of labor and equipment and on the management skills of each farmer.

Crops grouped as "forages" included alfalfa, hay, pasture, red clover, trefoil hay, oilseed radish, hairy vetch, and ryegrass (Table 2). "Small grains" were fall rye, oats, triticale, mixed grains and peas, barley, winter wheat, millet, and spelt. The crops categorized as "others" included soybean, corn, and flax. Most crops were used as feed, with only a few grown as cash crops.

Perennial forages

Alfalfa and red clover were the most common undersown crops with small grain seedings, presumably because of the combination of high nutritional value for livestock and the N contribution to the succeeding crop in the rotation. The excellent N-scavenging ability of alfalfa (Heichel, 1987) would also be beneficial in ensuring a "tight" N cycle on the organic farms.

Four of the dairy farmers completely integrated perennial forages such as hay and pasture into their crop rotations. They did not have separate permanent pasture or hay land. The inclusion of short-term forages in a grain crop rotation underscored the beneficial integrating role of perennial forages on a livestock farm. Forages were used not simply as livestock feed but also to control weeds and insect pests and to enhance and conserve the soil, all of which enabled sustained production of annual grain crops in the same rotation.

The other four farmers devoted 10 to 75% of their land to permanent hay or pasture, although three of them also integrated forage crops into some of their grain crop rotations. Permanent sod cover allowed soil organic matter to accumulate, as has been shown in many long-term studies reported by Stevenson (1982) and Briggs and Courtney (1989). Although deforestation and fossil fuel combustion are usually regarded as the main contributors to higher atmospheric levels of CO_2 and higher global temperatures, the CO_2 released from soil through cultivation-induced decline in soil organic matter also is important (Stevenson, 1982; Briggs and Courtney, 1989). According to Moore et al. (1989), total global carbon storage in the soil and detritus is more than double that in all terrestrial biota (1200 versus 550×10^{15} g C, respectively). Even a moderate net decline in soil organic matter would release an amount of CO_2 comparable to that attributed to deforestation today ($1\text{-}2\times10^{15}$ g C), yet the decline in soil organic matter under intensive annual cropping has been more than moderate (Pimentel et al., 1987; Gantzer et al., 1990).

Table 1. Crops grown on organic farms.

Crop	Scientific Name	Number of Farmers Growing Crop (of 8)
Alfalfa	*Medicago sativa*	5
Barley	*Hordeum vulgare*	7
Birdsfoot trefoil	*Lotus corniculatus*	1
Corn	*Zea mays*	1
Flax	*Linum usitatissimum*	2
Millet	*Panicum miliaceum*	1
Oats	*Avena sativa*	7
Oilseed radish	*Raphanus sativa*	3
Pea	*Pisum sativum*	2
Red clover	*Trifolium pratense*	5
Rye	*Secale cereale*	6
Ryegrass	*Lolium multiflorum*	2
Spelt	*Triticum spelta*	3
Soybean	*Glycine max*	2
Triticale	*Triticale hexaploide*	2
Hairy vetch	*Vicia sativa*	1
Winter wheat	*Triticum aestivum*	4

Table 2. Average number of years (of 5) in which forages and small grains were grown on organic dairy farms[1].

Farm No.	Forages	Small Grains	Others
1	2.5	2.0	0.5
2	3.0	2.0	0
3	3.5	1.5	0
4[2]	3.0	1.0	0
5[2]	2.5	1.5	0
6[2]	2.5	1.0	0.5
7	3.0	2.0	0
8	5.0	0.0	0

[1] When a crop was underseeded with a forage crop on the same field, the main crop and the underseeded forage crop were each counted as growing for 0.5 years. These crops were not necessarily grown consecutively for the indicated number of years.
[2] These farms gave only four years of rotation.

Reversing this trend may require the systematic reintroduction of perennial forages into contemporary crop rotations. Contrary to popular perception, conservation tillage, which is widely cited as a soil-conserving alternative to conventional plowing, slows the decline in soil organic matter but does not build it up (P. Voroney, Professor of Land Resource Science, University of Guelph, private communication, 1995). Thus, the livestock industry's dependence on perennial forage crops such as hay and pasture is not simply an agronomic and economic issue, but also a positive contribution to solving the global warming problem.

Small grains

On conventional dairies, rations typically feature corn grain or corn silage to supply concentrated carbohydrates, although good quality conserved forages (hay/haylage) can supply approximately 40-45% of the metabolizable energy ingested by dairy cows (B. McBride, Professor of Animal and Poultry Science, University of Guelph, private communication, 1995). On the surveyed organic dairies, small grain crops such as mixed grain, oats, and barley were the predominant carbohydrate crops. Organic producers preferred small grains because they are sown in narrow rows, which enhances competitiveness with weeds, conserves soil moisture, and protects against soil erosion. Also, nutrient demands with small grains are less than with corn. As a result, small grains are more compatible with the "feed the soil, not the crop" approach advocated by organic producers. Corn demands high nutrient availability in a short period in the summer; this can be difficult to achieve without risk of leaching and groundwater contamination.

Small grains also produce 40 to 60% the grain yield of corn, so that using these crops requires more land to supply the same amount of carbohydrates. It is consistent with this point that organic producers have more tillable land than do conventional producers.

Cover cropping

Organic producers placed a high value on maintaining year-round soil cover. Year-round cover immobilizes plant nutrients and reduces losses through leaching or denitrification, retards wind and water erosion, and increases soil organic matter. In this study, winter small grains, perennial forages, and annual catch crops provided winter cover 85% of the time (Table 3). To maintain more continuous cover, cover crops were commonly undersown into an existing, maturing crop rather than after the crop was harvested.

Some covers were leguminous, N-fixing crops, such as alfalfa, hairy vetch, and red clover. Besides their beneficial effect on soil N levels, forage legumes can supply concentrated protein for ruminants (Fulkerson, 1983). Although immature grasses also are high in protein compared with more mature plants, legumes generally contain 20–30% crude protein, which can supply most of the protein needed for lactating dairy cows.

Weed control and post-planting operations

None of the responding producers reported that weeds were a serious problem. Quackgrass was the most prominent weed on four farms (Table 4). Weed prevention received greater emphasis than weed control. The farmers selected a particular sequence of crops to discourage the establishment of management-adapted weeds. For example, the same small grain was never grown consecutively, and winter and spring small grains tended to be alternated when grown in sequence in the same field. Varying the kind and timing of cultivation to suit different crops discouraged build-up of particular weed populations. Composting of animal manure also was routine on all eight farms. This may have reduced weed seeds in the manure returned to the land (Stonehouse et al., 1993), although this effect is not universal (various studies cited in Karanja, 1994).

Other preventive measures included using narrow-row rather than wide-row crops, because narrow rows achieve full cover more quickly and shorten the period when weeds can encroach. The preference for cool-season rather than warm-season crops (e.g., small grains and forages versus corn, soybean, and common bean) also may accelerate the attainment of full cover in spring, when the challenge from annual weeds is greatest. Province-wide figures for herbicide use in Ontario support the perception that weed control is much less of an issue in small grains and perennial forages than in corn or soybeans. Small grains receive herbicides at about 0.5 kg active ingredient (a.i.) per ha, compared with about 3

Table 3. Average number of years (of 5) with winter cover on organic dairy farms.

Farm No.	Years	Crop Used as Cover
1	4	pasture, rye, winter wheat, spelt, alfalfa
2	3	red clover, hay
3	5	red clover, hay, alfalfa
4	3[1]	alfalfa, hay
5	3[2]	oilseed radish, alfalfa, red clover, winter wheat
6	4[1]	hay, oilseed radish, pasture, spelt, winter wheat
7	5	hairy vetch, oilseed radish, alfalfa, spelt, winter wheat
8	5	hay, pasture

[1] These farms had been operated for only four years using organic methods.
[2] Only four years of rotation were reported.

Table 4. Weeds found on organic dairy farms.

Weed	Scientific Name	Number of Farms with Weeds (of 8)
Quackgrass	*Elytrigia repens*	4 (major weed)
Bindweed	*Convolvulus arvensis*	1
Common ragweed	*Ambrosia artemisiifolia*	2
Wild mustard	*Brassica kaber*	3
Wild oats	*Avena fatua*	1

kg/ha for corn and soybean (adapted from OMAF, 1989, and Moxley, 1989). Although corn grain yield is much higher than that of small grains, the efficiency with which herbicides are used to produce grain yield is about 4700 kg grain/kg a.i. for small grains, compared with about 1500 kg grain/kg a.i. for corn. Thus, the organic dairy farms emphasize crops that are least dependent on chemical weed control and consequently most amenable to organic methods.

When organic farmers perceived weeds to be a problem, they managed them using various long-term and short-term practices, such as strategic inclusion of smother crops (e.g., buckwheat, rye, red clover, and oilseed radish), to control particular weeds. Because of its spring vigor, fall rye, for example, is reported to be beneficial in reducing quackgrass populations. Timeliness and frequency of field operations such as planting and cultivation also were used to reduce weed problems. For example, farmers delay spring planting to allow mechanical cultivation to reduce the weed challenge to spring-sown crops.

Soil and fertility management

Maintenance of soil fertility on a commercial organic farm can be achieved by a variety of practices (Macey, 1992), including purchase of approved nutrient sources such as rock phosphate and greensand. None of the surveyed producers imported bulk synthetic fertilizers to replace nutrients exported from the farm as milk or livestock. Because the amount of nutrients exported in livestock products is lower than with grain crops, and especially than with whole plant crops such as hay, the nutrient loss from organic dairies could readily be replaced using approved crop products and imported feeds.

Soil nutrients are highly valued and carefully conserved on an organic dairy farm, and as a result, nutrients found in manure, bedding materials, and other organic byproducts are recycled to replace the nutrients withdrawn from the soil by harvested crops. Composted solid manure was used on all eight dairy farms, while composted liquid manure also was applied on four. Liquid manure was composted using a microaeration system, which reportedly reduces both nitrogen losses from volatilization and malodorous emissions produced under anaerobic conditions (Macey, 1992). For solid manures, nutrient retention was encouraged by the amount and form of bedding materials, the shape and size of the compost windrow (Karanja, 1994), and on some farms, by a precomposting phase, which typically occurred on a sloped concrete pad. On one farm, a specially constructed covered composting shed protected against leaching losses.

Three of the responding farmers were members of the Biodynamic Society, which advocates a particular type of organic farming that includes the application of one or more "preparations" made from various natural substances (Pfeiffer, 1983). Specific preparations are intended for particular uses, such as to enhance soil fertility or stimulate composting. There is no equivalent to biodynamic preparations in other systems of agriculture (Koepf, 1981).

The three Biodynamic producers used Preparations 500 and 501 for soils and plants, following the standard composition and use as outlined by Koepf (1981). Preparation 500, based on cow manure, was applied at about 200 to 300 g/ha. Preparation 501 (finely ground quartz) was applied at 4 g/ha. Solutions prepared from each of the following were added to manure and compost at 2 to 4 ppm: yarrow (*Achillea millefolium*); scentless chamomile (*Matricaria perforata*); stinging nettle (*Urtica dioica*); oak (*Quercus* spp.) bark; dandelion (*Taraxacum officinale*); and valerian flowers (*Valeriana officinalis*) (these correspond to preparations 502 through 507, respectively).

Koepf (1981) reported that the efficacy of biodynamic preparations is shown in the yield and quality of crops and in the fermentation and the finished product from composting. Biodynamic preparations were applied twice after planting on two of the organic farms in this study, and up to four times on the other farm.

Feeding and animal health practices

Most crops grown on organic dairy farms were used on-farm as livestock feeds. Feed supplements such as minerals (salt, kelp, dairy premix) and vitamins were purchased. The four farmers who purchased feed obtained mixed grains, oil cake, soybean, and hay from other organic farmers.

None of the organic dairy farmers used synthetic additives or growth stimulants in feed rations. The farmers said that they did not use any additives because they were particularly interested in the health of their livestock. They further stipulated that they preferred their livestock to eat "naturally grown and healthy" feeds and produce as much milk as they could with those feeds, rather than supplementing with any conventionally grown feeds to try to increase milk yields. Two farmers said that they sampled forages for laboratory analysis several times a year to ensure that proper mineral and grain supplementation was fed. Six included pasture in the crop rotation; all eight included pasture as a crop in their land-use system, using controlled grazing.

The most commonly reported livestock health issues were milk fever, mastitis, and calf pneumonia. All eight farmers used homeopathic remedies, which emphasize prevention and early detection rather than treatment to control these diseases. However, the extent to which they depended on these homeopathic remedies differed. Seven used some probiotics or antibiotics and some drugs in conjunction with homeopathic remedies. Only one farmer used strictly homeopathic remedies on his dairy herd. Some farmers purchased remedies; two others prepared their own.

Homeopathy reportedly helps dairy cows to build immunity against diseases before they become established. Its use involves frequent observation of animals to detect emergence of any disease. Although all the farmers said that homeopathy had been very effective, they did resort to drugs when needed. Seven were willing to administer drugs in acute situations, rather than allowing cattle to die. Such a situation might arise if the farmer failed to observe the disease symptoms soon enough, because homeopathic remedies work too slowly to be effective in acute situations.

Motivations for adopting organic farming

The organic farmers reported diverse reasons for adopting organic farming. Seven had previously been conventional dairy operators. Of these, two said that they switched to organic farming because of the high cost of synthetic fertilizers and biocides and one because he hated the job of

pesticide spraying and objected to the high input cost of synthetic inputs, especially fertilizers; four said that they were more concerned about the environmental effects of chemical fertilizers, such as the potential for groundwater pollution. The remaining farmer adopted organic farming because of his religious beliefs and childhood background. The average time since these farmers had switched to organic methods was 5.5 years. One of them, however, had never used conventional farming approaches at all. The subject of motivation was not fully addressed in this study, but the limited information captured by the questionnaire suggests that profit maximization was not the farmers' primary motivation for adopting organic dairying. Rather, concern about the environmental impacts of agricultural chemicals appears to have been more important. These farmers sought to avoid longer-term costs associated with land degradation, even at the expense of short-term profitability, if necessary.

Limitations of the Study

These results must be regarded as preliminary because of several limitations in the scope and methods of the study:

- Sample size was small, although the eight surveyed farms represented a large portion of the organic dairies in the province.
- The representativeness of the eight surveyed dairies is unknown, although cooperators were identified in an unbiased way.
- Time and budget constraints made it impossible to visit the organic farmers to obtain additional information that may have made this study more informative. Most contacts were by mail and telephone. However, we made repeated efforts to ensure that we obtained accurate information.

Conclusions

Organic farming can be traced to the early 1900s, when it was associated with small farms. However, this study has shown that organic farming is not restricted to farms that are small, whether in land base or herd size. Organic dairying also is practiced on large commercial farms, where it is both feasible and productive. The main aspects distinguishing the organic farms we studied were crop selection and rotation, replacement of synthetic fertilizer and biocides by composted manure and management, and reduced use of purchased feeds and livestock. The organic farmers grew a variety of crops, with emphasis on forages (about 67% of their land base). Most crops were used as livestock feeds; some also were valued for winter soil cover and nitrogen fixation. Composted animal manure and nitrogen-fixing crops replenished depleted soil nutrients. Timeliness of field operations, rate and spacing of seeding, and the sequence of crops satisfactorily controlled weeds and other pests.

Although the tillable land base on organic dairy farms was higher than the provincial average, organic dairy farming was not more labor-intensive. However, it may demand more management. More time may be required in thinking, observing, and planning correct crop rotations and timing field operations. Organic farming was economically feasible and profitable because it maintains production levels while lowering costs.

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Senate Committee Bill Includes New Research Initiative

The Senate Agriculture Committee has approved the "Agricultural Research, Extension, and Education Reform Act of 1997," or research title, whose centerpiece is a new five-year research initiative with mandatory funding levels greater than those of the Fund for Rural America.

The "Initiative for Future Agriculture and Food Systems," which would be funded at $780 million over five years, would underwrite research in its first two years for food genome mapping; biotechnology; natural resource management, including precision agriculture; food safety and food technology; and new uses and products for agriculture commodities. After those two years, the Research Education and Economics Advisory Board would determine the initiative's future research priorities.

The Senate bill extended funding for the Fund for Rural America through 2001, at its current $100 million annual level. Under the bill, 50% of these funds would be allocated for rural development, 33% for research, and 17% for either purpose at the discretion of the Secretary of Agriculture. The Senate bill also incorporates a precision agriculture bill as an authorization for the USDA to conduct precision agriculture research.

The new research initiative, which emphasizes "technology silver bullets" such as precision agriculture and genome mapping, could eventually be merged with the Fund for Rural America, which emphasizes rural development, according to Kathleen Merrigan, Senior Analyst for the Wallace Institute. "We hope that won't happen, and would oppose that," she said. The debate about the research title will be focused on the new Initiative, according to Merrigan.

Management of natural Kentucky bluegrass-white clover pasture

William M. Murphy, Joshua P. Silman, Lisa E. McCrory, Sarah E. Flack, Abdon L. Schmitt, and Nthoana M. Mzamane

Abstract. *Management recommendations are needed for low-input (no N fertilizer) Kentucky bluegrass-dominant/white clover swards, particularly to increase or maintain white clover content. We applied treatments involving different amounts of forage present pre- and postgrazing, with and without harrowing and soil aeration, to a well-established, naturally seeded pasture grazed by dairy cows. Pregrazing dry matter was 2350 or 2700 kg/ha (about 10 or 15 cm tall). Postgrazing dry matter was 1100 or 1575 kg/ha (about 2.5 or 5 cm tall). The sward was composed mainly of Kentucky bluegrass, orchardgrass, quackgrass, timothy, white clover, dandelion, and chicory. Soil aeration and harrowing did not affect botanical composition, plant components, or forage yield. Pre- and postgrazing mass (total forage dry matter per unit area) did not affect botanical composition or plant components, but did influence total forage yield. White clover tended to increase under all pasture-mass treatments. During the second year the lowest postgrazing mass produced the most forage (mean: 6685 kg DM/ha). Forage quality of all treatments was excellent (seasonal means: 26% crude protein; 1.6 Mcal net energy lactation/kg DM).*

Key words: management intensive grazing, natural swards, sward dynamics, soil aeration, harrowing, forage production

Introduction

Information is inadequate about the effects of pre- and postgrazing mass (total forage dry matter [DM] present per unit area), soil aeration, and harrowing on North American pastures. We studied how sward botanical composition, plant components, and forage yield responded to different masses, aeration, and harrowing in a naturally seeded Kentucky bluegrass (*Poa pratensis*)-dominant/white clover (*Trifolium repens*) pasture under low-input (no N fertilizer) management-intensive grazing with dairy cows. We especially wanted to develop management recommendations to increase or maintain high white clover content in swards, because of its value in providing biological N to the whole farm and its excellent feed quality. Natural swards potentially can produce at least as much forage DM, energy, and protein as selected and seeded grasses such as perennial ryegrass (*Lolium perenne*) at low-to-moderate input levels of N fertilizer, if managed appropriately (Frame, 1985, 1991; Harkess and Frame, 1986). This kind of information is needed to feed livestock efficiently and profitably on 10 million ha of pastureland in the north central and northeastern United States.

W.M. Murphy is Professor of Agronomy, J.P. Silman is Research Technician, L.E. McCrory, S.E. Flack, and A.L. Schmitt are Graduate Students, and N.M. Mzamane is Assistant Professor of Agronomy, Department of Plant and Soil Science, University of Vermont, Burlington, VT 05446-0082.

Materials and Methods

The study was conducted during 1992 and 1993 on the Holstein dairy farm of Michael and Tammy Hanson near Fairfax, Vermont. The soil is a well-drained stony, sandy loam. The pasture sward was composed of Kentucky bluegrass, orchardgrass (*Dactylis glomerata*), quackgrass (*Eltrygia repens*), timothy (*Phleum pratense*), white clover, dandelion (*Taraxacum officinale*), and chicory (*Cichorium intybus*). The area had been seeded to alfalfa (*Medicago sativa*) seven years before, but the alfalfa had disappeared and was replaced naturally by these species. Before this study, forage had been machine-harvested from the area for ensilage or hay in late spring or early summer, then was grazed continuously until midsummer, when the overgrazed plants became dormant. Cows were then confined and fed in the barn until the following spring.

Fifty-five lactating cows were used to graze paddocks for 12-hour periods. Cows were given a fresh paddock after each milking, and were enclosed in paddocks during grazing periods; drinking water was provided in all paddocks. Target pregrazing pasture masses (dry matter basis) were 2350 or 2700 kg DM/ha (about 10 or 15 cm tall, respectively). To provide appropriate forage DM allowance for the cows outside the experiment, paddock areas were adjusted according to pregrazing mass. We allocated pasture forage DM to lactating cows on the basis of 3% of body weight equivalent per 24 hours. Experimental paddock size was fixed. Paddocks with low pregrazing mass were 0.25 ha (stocking density=260 animal units/ha; 1 AU=500 kg live weight). Paddocks with high pregrazing mass were 0.17 ha (stocking density=382 AU/ha). There were two replicates of each pregrazing-mass paddock.

Target postgrazing masses were 1100 or 1575 kg DM/ha (about 2.5 or 5 cm tall, respectively). For highest DM and nutrient intake, lactating cows first grazed paddocks down to 1575 kg DM/ha, followed by 15 dry cows and heifers that grazed paddocks down to 1100 kg DM/ha postgrazing masses (except in high postgrazing mass areas, which were fenced to exclude the later group). This eliminated the need to clip the pasture. The rest of the lactating cows' daily DM

requirement was provided as grain and forage supplements in the barn at milking times. Grazing began during the last week of April and lasted until mid-October each year.

Each postgrazing-mass treatment area was 12×30 m. Within each postgrazing-mass area, we applied all combinations of control (no mechanical treatment) and mechanical conditioning treatments to 3×30-m plots. Mechanical treatments were: harrowing with a Furst flexible-tine harrow; soil aeration with a heavily weighted Aerway aerator; and aeration followed by harrowing. We applied mechanical treatments in the same locations after the second rotation in May each year.

Experimental paddocks were grazed each time they reached target pregrazing masses as determined by 30 measurements along a zigzag line in each paddock with a single-probe capacitance meter (Pasture Probe). Before and after each grazing, we estimated the amount of pasture mass present in each treatment by taking a Pasture Probe measurement every 1 m along a straight line running the length of each 3×30-m plot. Just before grazing, four turf samples, 10-cm diameter by 2.5-cm deep, also were removed at random along a straight line running the length of each 3×30-m plot. Turf samples were refrigerated until dissected into the following components: grass tillers; white clover stolons, petioles, and leaflets; forbs; and dead material. Length of white clover stolons was measured and stolon growing points were counted. We did not attempt to separate tillers into individual grass species. All sample components were dried at 55°C, weighed, and ashed at 600°C for 2 hr (Jones, 1984) to remove soil contamination for botanical composition percentages based on ash-free organic matter. Forage samples were taken by hand plucking along a zigzag line in each paddock every two weeks for feed quality analysis using near-infrared reflectance spectroscopy.

We measured sunlight (photosynthetically active radiation, near-red, and infrared) transmittance to the sward base weekly in all 3×30-m plots with a ceptometer and spectroradiometer. This was done to determine when it is best to graze, based on reduction of sunlight transmittance in the sward as plants regrow after the previous grazing. (These methods and results are reported in Flack, 1994.)

The experimental design was a randomized complete block with nested treatments, replicated twice. We analyzed the data with standard analysis-of-variance procedures using SAS/STAT, a product of the Sas Institute, Inc.

Results and Discussion

Uniform grazing management of the cows was maintained outside and within experimental paddocks during both years. Throughout the farm we adjusted paddock sizes according to the amount of pasture mass present to provide the required amount of herd DM intake per 12-hr grazing period. Therefore, the range of pre- and postgrazing masses in the experiment was similar to what cows experienced on the rest of the pasture. This was important, because otherwise cows' grazing behavior might have been unusual in the experimental area, resulting in erroneous data.

Forage quality was excellent throughout the grazing season (Table 1). Maintaining pasture swards in a short (low pre- and postgrazing masses), immature stage of vegetative growth results in high forage quality throughout the grazing season (Nation, 1996).

Although soil aeration and harrowing have been beneficial under long-term continuous set stocking of cattle (McLaughlin, 1985; Davies et al., 1989), neither treatment, alone or in combination, affected forage production, botanical composition, or plant components under the management intensive grazing used here. Lack of response to aeration indicated that soil compaction did not limit plant growth on this coarse-textured soil. Harrowing to spread dung also proved unnecessary, possibly because the high stocking densities, short grazing periods, and lush forage resulted in thin, uniformly spread high-moisture dung that decomposed rapidly. An active population of earthworms was clearly present. Earthworm activity naturally aerates soil and incorporates manure.

Although the pre- and postgrazing masses did not significantly affect botanical composition or grass and legume components, important changes in the sward were evident during the second year (Table 2). Content of white clover (all plant components) tended to increase and dead material tended to decrease in the sward. These changes ultimately can improve forage quality.

White clover N and DM contribution varies within and between years, mainly because of grazing management, plant cultivar, and weather and biotic factors (Collins et al., 1991). Of these factors, frequency and intensity of defoliation has more influence on white clover content and stolon density in a mixed sward, because of its effect on light relationships (Harris, 1978; Curll and Jones, 1989). White clover is favored when sunlight regularly reaches stolon growing points. This is enhanced by grazing management that maintains low pre- and postgrazing masses, compared with undergrazed swards where white clover can be shaded out, especially when pasture mass accumulates above 3000 kg DM/ha (Kore et al., 1987).

Dead material tends to accumulate in undergrazed swards because at high levels of pasture mass (above 3000 kg DM/ha) shading kills low-growing plants and plant parts. A large amount of dead material in a pasture reduces palatability of the forage. Maintaining low pre- and postgrazing masses decreases dead material in swards, as more of the forage that is produced is consumed by livestock (Kore et al., 1987).

Pre- and postgrazing mass influenced total forage yield (Table 3). During the second year, when we would expect treatment effects to be more pronounced, an average of 889 kg DM/ha more forage was produced with low than with high postgrazing mass. This higher yield probably was due to more favorable conditions for plants treated with low postgrazing mass to intercept sunlight.

Table 1. Analyses of pasture forage on Hanson dairy farm, Vermont, 1992–1993.

Analysis	May	June	July	Aug	Sept	Oct	Mean
Dry matter (%)	21	19	18	17	18	19	19
Crude protein (%)	26	24	25	27	27	25	26
Net energy lactation (Mcal/kg DM)	1.7	1.5	1.6	1.6	1.6	1.6	1.6

Table 2. Sward botanical composition and grass and white clover components, May–October, Hanson dairy farm, Vermont.

	1992		1993	
	% by ash-free weight			
Grass	52	(1)[1]	41	(4)
White clover[2]	9	(1)	27	(6)
Forbs	16	(1)	14	(3)
Dead material	23	(1)	18	(4)
Grass tillers/m^2	9823	(225)	8591	(471)
White clover				
Leaves/m^2	679	(62)	770	(106)
Growing points/m^2	280	(3)	494	(59)
Stolon length, m/m^2	5	(0.7)	13	(2)
Seedlings/m^2	10	(4)	23	(8)

[1] Number in parentheses is standard error of mean.
[2] Includes stolons.

Conclusions

Soil aeration or harrowing treatments are not needed under grazing management that is appropriate for the plants, growing conditions, and livestock. Like all other inputs, if mechanical conditioning, such as aeration, harrowing, and clipping, can be avoided, farm profits should improve.

For swards similar to the one used here, we recommend that after each milking, the cows should be offered a fresh paddock with a sward having a pregrazing mass of 2350 to 2700 kg DM/ha at constant stocking density. Paddock sizes should be adjusted to allocate pasture forage DM according to the desired level of intake. For highest DM and nutrient intake, lactating cows can graze the paddocks first, leaving a postgrazing mass of about 1575 kg DM/ha, followed closely by dry cows and heifers that graze the paddocks down to about 1100 kg DM/ha. This management should result in consistently high forage quality, yield, and use of the forage produced.

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Table 3. Pre- and postgrazing mass (kg DM/ha) effects on total forage yield, Hanson dairy farm, Vermont.

	Mass (kg DM/ha)							
Pregrazing	2350				2700			
Postgrazing	1100		1575		1100		1575	
	Total yield (kg DM/ha)							
1992	4717	(99)[1]b[2]	3899	(107)b	5722	(134)a	5482	(130)a
1993	6903	(78)a	5191	(61)b	6467	(110)a	6401	(97)b

[1] Number in parentheses is standard error of mean.
[2] Total yields within a year row followed by different letters differ at $p<05$, Duncan's New Multiple Range Test.

INSTITUTE NEWS

New Report Examines Industrialized Agriculture and Direct Marketing

A new report from the Wallace Institute focuses on the rise of "industrialized" agriculture and the increasing popularity of direct marketing of agricultural products. "In industrialized agriculture, farm-level control over agricultural production operations is being replaced by corporate control, which relegates farm-level workers to the role of hired labor," according to *Reorganizing U.S. Agriculture*, the second installment in the Institute's ongoing investigation of structural change in U.S. agriculture. "In direct marketing, farmers exercise substantial control over their products, from cultivation or weaning to final sale."

The report looks at the legal environment in which industrialized agriculture and direct marketing have evolved; how they have affected the distribution of control within agriculture; and what measures have been taken to alter that distribution of control. It recommends research to answer questions posed by the changing structure of agriculture. The report is $6 from the Wallace Institute, 9200 Edmonston Road, #117, Greenbelt, MD 20770; (301) 441-8777; e-mail hawiaa@access.digex.net.

Senator Leahy Wins Organic Leadership Award

Senator Patrick Leahy (D-VT), a member of the Wallace Institute's President's Council, is the first recipient of the Organic Trade Association's Organic Leadership Award, which was presented to him in September.

The new award acknowledges "leadership and vision in the furtherance of organic agriculture," and is being given to Senator Leahy for his "leadership in sponsoring the Organic Foods Production Act and his long-standing support of organic agriculture," according to the association. "During his 23-year tenure on the Senate Agriculture Committee, Leahy has been a steadfast supporter of organic agriculture and farmers."

Wallace Board Approves New Journal Editor At Mid-Year Meeting

The Wallace Institute's Board of Directors, at its mid-year meeting in Salinas, California, on September 5-6, approved the appointment of Dr. Robert I. Papendick to be the new Editor of *American Journal of Alternative Agriculture*, the Institute's quarterly, peer-reviewed journal of research on alternative agriculture. Dr. Papendick, currently Professor Emeritus in the Department of Crop and Soil Science at Washington State University, had previously been a research soil scientist with the USDA's Agricultural Research Service for almost 30 years.

Dr. Papendick, who assumes the editorship in January, 1998, succeeds Dr. Willie Lockeretz, Research Professor at Tufts University, who has edited *AJAA* since its inception in 1986.

After a reception on September 5 at the Emma Prusch Farm Park in San Jose, the Board of Directors met on September 6 at the Rural Development Center, directed by Jose Montenegro, a member of the Wallace Board. The Center, a project of the Association for Community Based Education, runs a Small Farm Education Program, a community-based agricultural education program designed to meet the needs and aspirations of low-income people seeking greater self-reliance.

After its meeting, the Board toured the Center and sustainable agriculture activities nearby, including the Elkhorn Slough Watershed Project, which seeks to reduce soil erosion and improve water quality in the strawberry fields of the watershed. The Board also toured the organic family farm of Phil Foster in Hollister.

Wallace Institute Names Members of President's Council

Dr. Frederick L. Kirschenmann, President of the Wallace Institute, has announced the members of the 1997-1998 President's Council, formed seven years ago to provide guidance and support for Wallace Institute activities in promoting a more sustainable agricultural system in the United States and abroad.

Members are: Dr. Charles Benbrook, Benbrook Consulting Services; Norman A. Berg, Washington Representative, Soil and Water Conservation Society; Hon. George E. Brown, Jr., U.S. House of Representatives; Robert Gray, Resource Management Consultants; Ralph Grossi, President, American Farmland Trust; Dr. R. Jim Hildreth, Elmhurst, IL; Ms. Dana Jackson, Land Stewardship Project; Dr. Dennis R. Keeney, Director, Leopold Center; Hon. Patrick J. Leahy, U.S. Senate; Dr. Ned S. Raun, Stillwater, OK; Ronald L. Rosmann, farmer, Harlan, IA; R. Neil Sampson, Executive Vice President, American Forestry Association; Edward Sills, Pleasant Grove Farms, Pleasant Grove, CA; Dr. David G. Topel, Dean, College of Agriculture and Director of Experiment Station, Iowa State University; and Dr. Stephen Viederman, President, Jessie Smith Noyes Foundation.

Farmers Take the Lead in Protecting Ohio Watershed

Farmers are taking the lead in the Big Walnut Water Quality Partnership, a project designed to protect the natural resources of an important watershed in central Ohio. The initiators and decision-makers of the partnership are farmers and other land owners from the Big Walnut Creek watershed who serve on the board of trustees. "This is the first time that I know of that farmers have been in on a watershed project from the very beginning instead of being told what to do," said Bob Weiler, a farmer from the area.

Farmers in the project are committed to soil-conserving farming techniques, other best management practices, and responsible use of pesticides to ensure water quality. Support for the project comes from local, state, and federal agencies, including the USDA's Natural Resources Conservation Service.

RESOURCES

"Steel in the Field: A Farmer's Guide to Weed Management Tools" is $18 from Sustainable Agriculture Publications, Hills Building, University of Vermont, Burlington, VT 05405-0082; (802) 656-0471.

"New Opportunities For No-Till Rotations" is $8.95 from No-Till Farmer, P.O. Box 624, Brookfield, WI 53008-0624; 1-800-645-8455.

"Good Earth Guide" to organic growers is $5 from Ohio Ecological Food and Farm Association, P.O. Box 82234, Columbus, OH 43202; (614) 294-3663.

"Sustainable Agriculture in Montana: Its Social, Economic and Agronomic Impacts" is available from Alternative Energy Resources Organization, 25 S. Ewing, #214, Helena, MT 59601; (406) 443-7272; e-mail aero@desktop.org.

Sandy Bar Ranch seeks people interested in collective living and permaculture; contact the Ranch, P.O. Box 347, Orleans, CA 95556; (916) 627-3379; e-mail sandybar@earthlink.net.

"Tough to Swallow: How Pesticide Companies Profit from Poisoning America's Tap Water" is $23 from Environmental Working Group, 1718 Connecticut Ave., NW, #600, Washington, D.C. 20009; (202) 667-6982; or on the World Wide Web at http://www.ewg.org.

"Sustainable Agriculture in Print: Current Books" is available from Alternative Farming Systems Information Center, National Agricultural Library, 10301 Baltimore Blvd., Beltsville, MD 20705; (301) 504-6559; e-mail afsic@nal.usda.gov.

"Free-Range Poultry Production and Marketing" is $39.50 plus $4.50 shipping from Back Forty Books, Dept. A, 26328 Locust Grove Road, Creola, OH 45622; (614) 596-4379.

"Toward Organic Integrity: A Guide to the Development of U.S. Organic Standards" is $25 from Rural Advancement Foundation International, 101 Hillsboro St., #5, P.O. Box 640, Pittsboro, N.C. 27312; (919) 542-1396.

"Nutrient Management: Crop Production and Water Quality" (NRAES-101), $8; **"Nutrient Management Workbook"** (NRAES-102), $2.50; and **"Estimating a Mass Nutrient Balance"** (NRAES-103), $1.50, are available from Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Ithaca, N.Y. 14853; (607) 255-7654; e-mail NRAES@CORNELL.EDU. Please add $3.50 shipping.

"Economics Research and Education Priorities for an Efficient and Sustainable Food System" is available from Tracy Irwin Hewitt, Council on Food, Agricultural and Resource Economics, 726 F St., NE, Washington, D.C. 20002; (202) 544-2145; e-mail itracy@aol.com.

"Dynamic Farmers' Marketing: A Guide to Successfully Selling Your Farmers' Market Products" is $14.95 plus $2.50 shipping from Bittersweet Farmstead, P.O. Box 52, Middlebrook, VA 24459; (540) 886-8477; e-mail ish-bittersweet@juno.com.

"Hoop Structures for Grow-Finish Swine" (AED-41) is $4 from University of Minnesota, Biosystems and Agricultural Engineering Dept., 219 BAE Bldg., 1390 Eckles Ave., St. Paul, MN 55108, attn: Terry; (612) 625-7024.

"Paddock Shift: Changing Views on Grassland Farming" is $25.95 from Stockman Grass Farmer, P.O. Box 9607, Jackson, MS 39286; 1-800-748-9808.

Publications list is available from Yankee Permaculture, P.O. Box 52, Sparr, FL 32192; e-mail YankeePerm@aol.com.

UPCOMING EVENTS

December 2, "Partners for Smart Growth" will be held in Baltimore, MD; contact Urban Land Institute, 1-800-321-5011; e-mail smartgrowth@uli.org.

December 7, "Midwest Fish and Wildlife Conference" will be held in Milwaukee, WI; contact Laura Paine, (602) 262-6203; e-mail lkpaine@facstaff.wisc.edu.

January 14, 1998, Southern Region SARE PDP/Chapter 3 Annual workshop will be held in Memphis, TN; contact Roseanne Minarovic or Roger Crickenberger, (919) 515-3252; e-mail rcricken@amaroq.ces.ncsu.edu.

January 21-24, 1998, 18th Annual Ecological Farming Conference will be held in Pacific Grove, CA; contact Committee for Sustainable Agriculture, 406 Main St., #313, Watsonville, CA 95076; (408) 763-2111.

January 22-25, 1998, Southern Sustainable Agriculture Working Group Annual Conference and Trade Show will be held in Memphis, TN; contact Jean Mills, (205) 333-8504; e-mail jeanmills @aol.com.

January 26-28, 1998, National Conservation Buffers Technology Conference will be held in San Antonio, TX; contact Lyn Kirschner, Conservation Technology Information Center, (765) 494-1827; e-mail kirschner@ctic.purdue.edu; on the Internet, http://www.ctic.purdue.edu.

January 27-28, 1998, "Working with Wetlands and Wildlife" will be held in Sacramento, CA; contact Wildlife Habitat Council, 1010 Wayne Ave., #920, Silver Spring, MD 20910; (301) 588-8994.

January 28-February 1, 1998, 3rd Annual Herb Business Winter Getaway Conference will be held in San Antonio, TX; contact the Herb Growing and Marketing Network, P.O.Box 245, Silver Spring, PA 17575; (717) 393-3295; e-mail HERBWORLD@aol.com.

January 30-31, 1998, "Sharing the Lessons of Organic Farming," the 17th Annual Organic Conference and Eco-Products Trade Show will be held at the University of Guelph, Canada; contact Tomas Nimmo, Canadian Organic Growers, Box 116, Collingwood, Ontario, Canada L9Y 3Z4; (705) 444-0923; on the Internet, http://www.gks.com/OrgConf/

March 5-6, 1998, "Building on a Decade of Sustainable Agriculture Research and Education: Sharing Experiences to Improve Our Agriculture," sponsored by the USDA SARE program, will be held in Austin, TX; contact SARE, 0322 Symons Hall, University of Maryland, College Park, MD 20742; (301) 405-5270; e-mail vberton@wam.umd.edu.

Guide for Authors

The American Journal of Alternative Agriculture (AJAA) publishes original research on biological, physical, or social science aspects of alternative agriculture. We particularly welcome multidisciplinary studies, but papers from a specific discipline also are invited. However, since AJAA readership is much broader than for a single-discipline journal, highly specialized terminology should be explained or avoided. The significance of a statement, or the reasoning behind a conclusion, may have to be spelled out more than in a more specialized journal. See Vol. 5, No. 1, pp 2 & 3, for an explanation of the various categories of articles.

Units

Research papers should use the International (SI, or metric) system throughout. Occasional use of common unit equivalents in parentheses is permitted.

Title page

The title page should give the following information (all flush left): 1) title of the paper; 2) names of the authors; 3) affiliation and office address of authors, and 4) disclaimers and publication number, if any. See examples in this issue of AJAA.

Abstract

The abstract should be 200 to 400 words suitable for readers from a broad range of disciplines. It should avoid highly-specialized terminology that might be appropriate for a single-discipline journal. Take particular care that the significance of the work is made clear, even to readers from a different field.

Key Words

Provide subject matter key words suitable for use in scientific indexing.

Reference List

When citing material that has been covered in more than one format, such as the typescript of a conference presentation and a journal article, preference should be given to the version that is most readily available, and that is likely to remain so. Generally this means standard publication channels, such as books, journals, and regular government report series. Unpublished or informally-published material should be cited only when no alternative form exists.

References should be listed in alphabetical order by author's name, and by year for a particular author (with letters after the year if needed). If a sole author is also the lead author of papers with multiple authors, use the following order: single author (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized.

Citing References

Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

Manuscript Preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Every figure and table should be mentioned at least once in the text.

A detailed guide to formatting is available from the editor (address below).

Submission of Manuscripts

The editorship of the AJAA wil be changing on January 1, 1998. After that date, manuscripts should be submitted to the new editor, Dr. Robert I. Papendick (see below). Before that date, please submit manuscripts to the current editor, William Lockeretz, Editor, American Journal of Alternative Agriculture, School of Nutrition Science and Policy, Tufts University, Medford, MA 02155.

Submit four high-quality copies to Dr. Robert I. Papendick, Department of Crop & Soil Science, 253 Johnson Hall, Washington State University, Pullman, WA 99164-6420. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form, that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of family farms and rural communities.

Alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, enhanced environmental quality, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Henry A. Wallace Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Wallace Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

If you're interested in helping us, please contact the Henry A. Wallace Institute for Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, Maryland 20770-1551. Telephone: 301-441-8777; E-mail: hawiaa@access.digex.net; Web site: www.hawiaa.org

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